

The AMSAT[®] Journal

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WHITHER THE HAMSATS?

by Keith Baker, KB1SF, Executive Vice President

Many of you may recall my guest editorial in Bill Tynan's Apogee View a few months back, where I discussed some of the issues facing us as we move into the next century. Since that time, there's been a lot more discussion about the future of Hamsats in general and AMSAT in particular. I'd like to think that our editorial got some of you seriously thinking about the future of your organization. For example, a subject thread developed on AMSAT's Internet Bulletin Board in March, 1995 centered directly on the issues of future satellites beyond Phase 3-D, as well as the direction AMSAT should take to capitalize on the technology and launch opportunities of the future.

For those of you who contributed to the spirited AMSAT-BB discussion, you may not have been aware that your AMSAT leaders were also listening, albeit silently and in the background, so as not to bias the ongoing discussion. Many of us captured, read and then archived every word. The result was nothing short of a brilliant and far-reaching discussion on the central issues facing our organization in the future if we are to continue in the forefront of aerospace technology.

For those who may not have had access to the discussions, I thought it appropriate to quote, summarize and consolidate many of the comments made, and then attempt to put them in perspective. I'll add some other key issues affecting our future that may not be generally known. My objective is to keep the discussion going, and also to look for ways to enlist your individual help in moving us into the next century.

SHOULD WE BUILD MORE ANALOG FM BIRDS?

One central theme that played out early in the discussion examined the need for more analog FM birds like AO-21 and AO-27. Dan Schultz, N8FGV, even acted as consolidator for an informal poll of comments regarding this issue. His results seemed split between those who've had success with the FM birds and those who've had nothing but frustration getting into the transponders. The results of Dan's informal poll indicated that these satellites were wonderful tools to help get beginners interested in satellites. However, beyond this role, their effectiveness

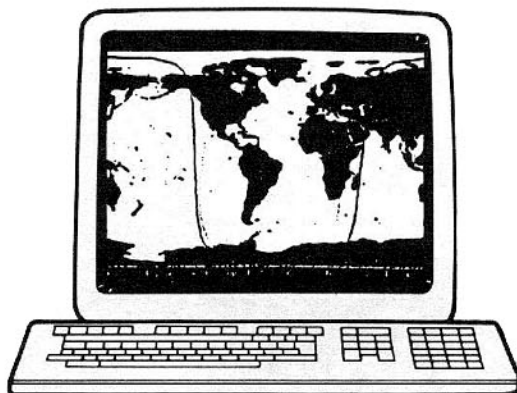
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by Bill Tynan W3XO

Keith Baker's guest editorial in the November/December issue of the Journal prompted a number of responses. Many have been quite thought provoking and offered good suggestions for future amateur satellite projects. Unfortunately, however, the tone of a few were rather negative asserting that THEIR approach, most advocating one or more geostationary satellites, is the ONLY acceptable course. They question why we are asking ourselves where we should be going after Phase 3D, when AMSAT was engaged in a geostationary project (Phase 4) in the late 1980s. A few charged that, since the geostationary approach is not the one being pursued currently, AMSAT leadership is not doing a proper job for its members and the amateur satellite community. Some chided AMSAT and ARRL to "get on with the real job".

Before I comment on some of these statements, I want to state my personal belief that a constellation of geostationary satellites is the most desirable means of providing amateurs with reliable continuous wide-range communication. The goal of providing amateurs with a one hundred percent reliable communication facility available 24 hours per day, has always driven my participation in AMSAT from its earliest days. So, on that point, I happen to be in agreement with advocates of the geostationary approach. Nevertheless, wanting something and having it are two very different things; especially when it comes to something as complex and expensive as amateur satellites.

Although I, as an individual, may favor the goal of amateurs eventually having access to one or more geostationary satellites, that is not necessarily the opinion of all members of the AMSAT Board of Directors. There are those who make a very good case for other approaches, such as a constellation of LEOs. Their view is based, at least in part, on what they perceive AMSAT can accomplish over the next five or ten years. In the process of making decisions on future tasks, it is very

important to understand what a mostly volunteer group of workers, without the financial resources available to large commercial enterprises, can realistically be expected to accomplish.

My own opinion notwithstanding, I must be guided by the counsel of those who have been in the forefront of amateur satellite design and construction for many years.

The principal reason that Phase 4 was shelved is that we found ourselves unable to raise sufficient funds, exclusively from Western Hemisphere sources. Some of those critical of the current approach, have argued that AMSAT won't require the support of the rest of the world in the construction of a geostationary satellite, as we have with Phase 3D. They contend that we can obtain funding from the Federal government, or possibly the American Red Cross. The Federal Emergency Management Agency is one specific source of Federal funding cited. As a matter of fact, AMSAT, during its efforts on Phase 4, did hold extensive discussions with Federal government Officials, specifically representatives of the National Telecommunication and Information Administration (NTIA). At the time, there were indications of possible government funding for an amateur geostationary satellite. Later, this hope proved to be elusive at best. Failure to obtain NTIA funding was one of the factors that prompted the AMSAT Board to shelve the Phase 4 Project in October 1990. As a Board member, I concurred in that decision, although it pained me to do so. If those proposing government funding feel that the prospects for it are more positive now than in 1990, I invite them to work with us in drafting appropriate proposals and to participate in the follow-up necessary to make it happen. We, those whom the AMSAT members have asked to represent them, will be glad to work with anyone who wishes to be constructive and take on needed tasks.

However, in my opinion it is probably more difficult to secure Federal money now than it was five years ago. Whether or not government funding might be forthcoming, I would not look forward to going through

the hassles which accompany attempts to get money from Uncle Sam. Certainly, AMSAT would have to add paid staff, in addition to our single full-time employee (Martha), just to supply the government with the continuous stream of reports it requires of any organization on the Federal dole. Ask anyone in the contracts and grants department of any university. Some contended that AMSAT should build a relatively simple satellite based on the Phase 3D design, without the liquid propulsion system. To get from Geostationary Transfer Orbit (GTO), which a launch vehicle would put us into, to the final spot in the Clark Belt; one respondent proposes the use of a Payload Assist Module (PAM). I am sure that the person making this suggestion has no idea what a PAM would cost. Without some research, I don't know either, but I'd venture to guess that it would be many times the cost of Phase 3D. Goodness knows how hard we are working to raise sufficient funds to complete that international project. I can assure you that It could not be done without the significant contributions of money, labor and expertise coming from outside North America. These contributions were not forthcoming in the Phase 4 Project, simply because it offered only Western Hemisphere coverage.

It was alleged by one respondent to KB1SF's editorial that the Phase 3D design can be easily adapted for use in a geostationary orbit spacecraft. But, such a modification is not as simple as one might think. While some of the design concepts embodied in Phase 3D might be adaptable to a spacecraft for geostationary orbit, many are not, and are specifically aimed at the Molniya type orbit in which Phase 3D will be placed. Therefore, significant redesign would be necessary. At this moment, I don't know where the people to accomplish such redesign would come from even if we wanted to make such a change - which we don't. That, along with the kinds of satellites we want, who will build them, where the launches will come from, and the sources of funding, and a myriad of other hard questions, are a part of what KB1SF and the rest of the Board are pondering in the study of what we do after Phase 3D. See "Whither the Hamsats?" in this issue of the Journal. Yes, we do need to be asking where we should be going. Geostationary satellites, even though I may favor them in principal, are NOT the only

approach. Their design, building and launching involve some major technical, manpower and fiscal challenges, especially if we must accomplish the job on our own, without the significant participation we are getting from the rest of the world in the Phase 3D Project.

But, no matter what specific approach AMSAT takes over the next decade, we must have more help from more of our members.

Those who can offer positive suggestions and are willing to work to help make them come to fruition, are most welcome. I am convinced that, if our organization is to continue as a satellite building group, we must have increased participation by those among our membership who are competent in a variety of jobs. ■

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[HAMSATS, Continued from page 1]

as a sustainable, high volume communications medium was sometimes offset by a handful of people who tended to monopolize the single transponder with high powered signals and/or long-winded ragchews. I also saw this same complaint recently aired on AMSAT-BB by frustrated users attempting contact with MIR, SAREX and AO-27.

Walt Daniel, KE3HP, took a more technical look at the FM mode by examining the link calculations needed for a MICROSAT class FM transmitter in Low Earth Orbit. His calculations indicate that the link equations for the downlink budget were barely acceptable for FM voice and/or 1200 bps packet even without factoring in losses due to polarization, antenna nulls, atmospheric and feedlines. Walt then took the issue one step further by examining the link budget for a MICROSAT FM satellite in a Phase 3D 3D-type elliptical orbit. The results were even worse. Walt concluded his discussion by pointing out that AO-21 was not a Microsatellite, but, rather, was attached to a much larger satellite and benefited from the parent satellite's much larger power budget and pointing control.

Based on Dan's and Walt's analysis, it appears that unless lots of satellite power is available to support multi-channel FM operation, an FM-only satellite seems to have its best usage as an introductory bird. That is, for use by those who simply want a taste of satellite work. However, FM operation for anything more than brief greeting contacts is going to require a satellite with multiple transponders. This translates into a lot bigger bird with a lot more available onboard power.

FM is a key-down, power hungry mode. That is, there is no time sharing of satellite power among several simultaneous users as with SSB and CW signals. An FM signal also occupies some 4 to 5 times the bandwidth of an equivalent SSB or CW signal. For comparison, I'm told the now silent AO-21 "FM" transmitter had an output power of about 10 watts. Add the laws of physics to this equation, and I think it should be obvious that even a 10 channel FM bird in low Earth orbit is going to be in the 100-watt-plus power category. That's some three times the power that's currently running everything now aboard Oscar 13 and

over 20 times that of the MICROSATs! Still, even with all this available power, only 10 people will be able to work the new bird at any given time. Under this scenario, it's no wonder some might argue that instead of a single monopolized and unusable channel in orbit, we'd now have 10!

Put such a satellite in an elliptical orbit similar to Phase 3-D, and the link budgets force even higher power requirements. Imagine if we were building Phase 3D to have only 10, or even 20 available channels, versus the hundreds with SSB and CW now planned, not to mention P3-D's digital capabilities. Would you support its development and launch as generously as you have? I'm concerned such an approach might require far more financial resources than AMSAT can effectively muster. However, I still believe the FM concept needs to be explored further, lest we discard new, as yet undiscovered or innovative approaches to this age old design dilemma before they've have a chance to mature.

OTHER FUTURE TRANSPONDERS

Another thread that wound its way through the recent discussions centered on a "if-not-an-FM-bird-then-what?" concept for future AMSAT satellite transponders. In this discussion, Phil Karn, KA9Q, ably pointed out that many of the cutting edge modulation schemes are digital, but that the technology is now staying on the ground versus being hard-wired into the satellite. Indeed, Phase 3D's digital RUDAK transponder will be carrying both a 9600 baud FSK modem as well as some digital signal processing (DSP) equipment to take full advantage of some of these new technologies as they mature. Phil goes on to make the point that, "...for satellite users interested in communicating in real time with each other over a wide area, it's really hard to beat a dumb "bent pipe" in high orbit." This becomes especially true when users invent a modulation scheme that wasn't available when the satellite was launched.

As I noted in our Journal editorial a few months ago, we in AMSAT are carefully watching the experimental development of just such a bent pipe transponder for possible use on a future, as yet unspecified, AMSAT satellite. As this issue of the Journal goes to press, I understand hardware is being procured and terrestrial testing should begin

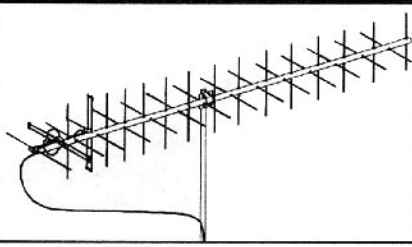
later this summer. Initial design results are encouraging, but only time will tell if theory can be successfully transformed into usable hardware. How such a wideband transponder might be used, and how we might get it to orbit, are challenges that still remain to be overcome.

SO HOW ABOUT A GEOSAT?

Many AMSAT groups from around the world are now working hard to make the Phase 3D program a success. However, as many of you well know, AMSAT was actively pursuing the construction and launch of a geostationary satellite in the late 1980s under the Phase 4 program. Unfortunately, that project was shelved when it became increasingly apparent the financial support from its prime audience (amateurs in the Western Hemisphere) was not forthcoming. It was at this time AMSAT-NA combined forces with the team headed by AMSAT-DL to build and launch Phase 3D. The rest, as they say, is history.

Now, nothing precludes us from again examining a geostationary satellite project

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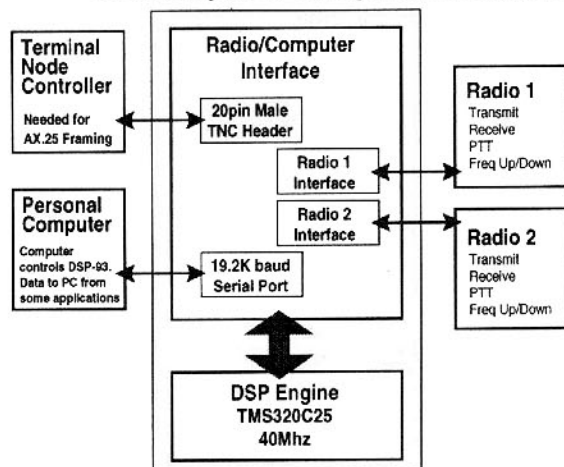
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once Phase 3D is safely in orbit. Presumably, we are a bit farther down the road technologically than when the Phase 4 concept was shelved in favor of Phase 3D. If we were to capitalize on the "lessons learned" as outlined by Phil Karn in his discussions referenced above, a bent pipe transponder in geostationary orbit offers us some very interesting potential as a follow-on project. On the other hand, one of the biggest hurdles this concept is going to present to AMSAT in the near future will be assembling the team to build it, even if we are fortunate enough to secure a low-cost launch.

From my perspective on the Phase 3D Development Team, I can tell you unequivocally that Phase 3D will be the last satellite to benefit from the talents of many of our dedicated experimenters. There are a variety of reasons, but most center on these outstanding people wanting to take a well-deserved break after their near constant involvement in building a string of successful AMSAT satellites. Unfortunately, in far too many critical areas our retiring experimenters are "one deep".

For others, available spare time to work AMSAT projects has already, or soon will become, an ever-shrinking, scarce commodity. Unfortunately, the talents needed to build and launch a satellite are not available on every street corner, and are becoming more specialized, not less. Often, these skills are only honed after years of hands-on experience. They are also in great demand in the well-paid private sector.

Assuming we could pull a design and construction team together, an inviting prospect is launching a "piggy-back" transponder on a geostationary host satellite. The next big problem will be that of finding a host satellite owner who would be willing to carry us along. That's because every extra ounce of payload these satellites must carry to geostationary orbit is usually offset by reduced station-keeping propellant to extend on-orbit lifetime. Contrary to popular belief, the leading cause of death for geosats is exhaustion of their station-keeping propellant long before the electronic systems give out. Given a choice between carrying a "freebie" AMSAT payload and extending the commercial money-making lifetime of a

geosat, it doesn't take a rocket scientist to figure out which alternative's going to have the upper hand, at least initially.

So, given all of this doom and gloom, should we totally abandon our quest for an AMSAT geosat, or, for that matter, any other major satellite project? Not at all! These issues simply make securing a geostationary presence for an AMSAT payload that much more difficult. But they don't rule it out altogether. Put another way, I think we've learned what's not doable for a group like AMSAT. But, I firmly believe we have yet to seriously explore what is!

LAUNCH OPPORTUNITIES FOR THE "FINANCIALLY CHALLENGED"

I hope all of you read the excellent article by Phil Chien, KC4YER, in the last issue of the Journal regarding launch opportunities beyond Phase 3D. In it, Phil listed a number of potential launch opportunities that, had we been in the right place at the right time with the right equipment, AMSAT could

have orbited a number of payloads into a variety of orbits (including some very attractive Geostationary ones) for next to nothing in financial outlay.

I think the key words here are "in the right place at the right time", because that's where each and every AMSAT member is going to have to lend a hand in the future if we are to progress beyond Phase 3D. In my previous editorial I was serious when I said that each of us is going to have to become a personal "Ambassador for AMSAT" in the future if we are to secure donations, obtain the needed design and construction labor, and then locate and exploit innovative launch opportunities. Had any one of us become aware of one or more of the launches Phil outlined in his Journal article in enough time for our leadership and experimenters to react, we might already have our Geosat (or any number of other attractive LEO satellites) in orbit.

Much to many people's surprise, the current leadership and core experimenter group of

AMSAT amounts to little more than a handful of people. However, our active membership numbers some 7500. Many of our members are well-placed in the aerospace industry and have daily access to the kinds of information and influence that could enable us to successfully present our case for a substantial donation...or a launch opportunity. It is simply impossible for your AMSAT leaders to know about, let alone exploit, every potential donation of equipment, materials, or test facility time that might come our way in the future. And, yes, the same logic applies to launch opportunities.

VISION

Sadly, people who think they're really helping our cause by writing well-intentioned letters about what "AMSAT should do" aren't nearly as helpful to us as those who are willing to take those first exploratory steps on our collective behalf. For example, what we really need are the kind of people who will, on their own,

draw a group of volunteers together to explore and prototype an innovative transponder idea, or begin exploiting material donations, testing or launch opportunities when they first come along. These people will look at our current AMSAT software and publication lineup and see what might be added or improved upon for the future, and then will either write it themselves, or pull a team together to do it. These are the same people who will compose an article for the Journal without being asked to, or who will arrange to set up an AMSAT hamfest booth or forum talk where none has been done before. In other words, AMSAT people who routinely find a need and fill it are going to be the ones who will keep our organization fresh and alive as we move into the late 1990s and beyond.

Each of us, individually, makes up the collective whole we call AMSAT. Each of us brings something of unique value to the organization, be that engineering expertise, leadership skills, organizational and administrative talents, or contacts with



PacComm has the most options for 9600 bps satellite work. All built from the G3RUH Direct FM design.

- The MC-NB96 modem card fits any PacComm TNC, or TNC-2 clone to upgrade it to 9600bps.
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people and organizations who can help us achieve our goals. I also believe each of us carries that same "can do" attitude as well as a spirit of exploration and innovation that was present when our AMSAT charter members met in that Washington apartment building back in 1969 to first form our organization.

Your leaders don't have all the answers. That's why I thank each of you who took the time to create such a superb discussion on the critical issues regarding our future. You gave all of us a wealth of ideas to consider. Now, I encourage each of you to not only continue these discussions, but to also help us seek out and exploit those opportunities that will insure AMSAT continues to prosper as we head into the next century.

....AND THEN THERE'S THE INTERNET

The naysayers among us will tell you that in this age of the Internet, the World Wide Web, and instant, on-line communication that the days of Amateur Radio (not to mention the Amateur Satellite Service) are numbered. Now, don't get me wrong, the Internet is a valuable tool, and has allowed many of us in AMSAT to better communicate among ourselves. I use it daily to keep in touch with my counterparts on the Phase 3D Development Team, as well as with many of our members. However, there is an equally strong argument that says these on-line substitutes will never replace what we do.

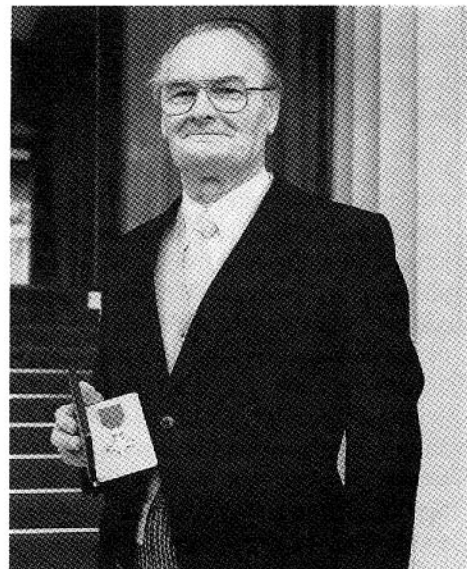
Someone once told me that building, launching and working through our satellites is a lot like fishing. Anyone can go to the fish market to buy fish. However, there will always be those who still prefer to go catch their own.

Ron Broadbent, G3AAJ, Awarded Order of the British Empire

Ron Broadbent, G3AAJ, was awarded the Order of the British Empire by Queen Elizabeth in a ceremony at Buckingham Palace in London. The official citation was "for Services to the Amateur Radio movement and the Amateur Satellite Service." This is only the second time a member of the amateur radio community received such an honor and the first time the honor has been given by the Queen for Amateur Radio Services etc. The previous honor was to Roy Stevens, G2BVN who was IARU General Secretary.

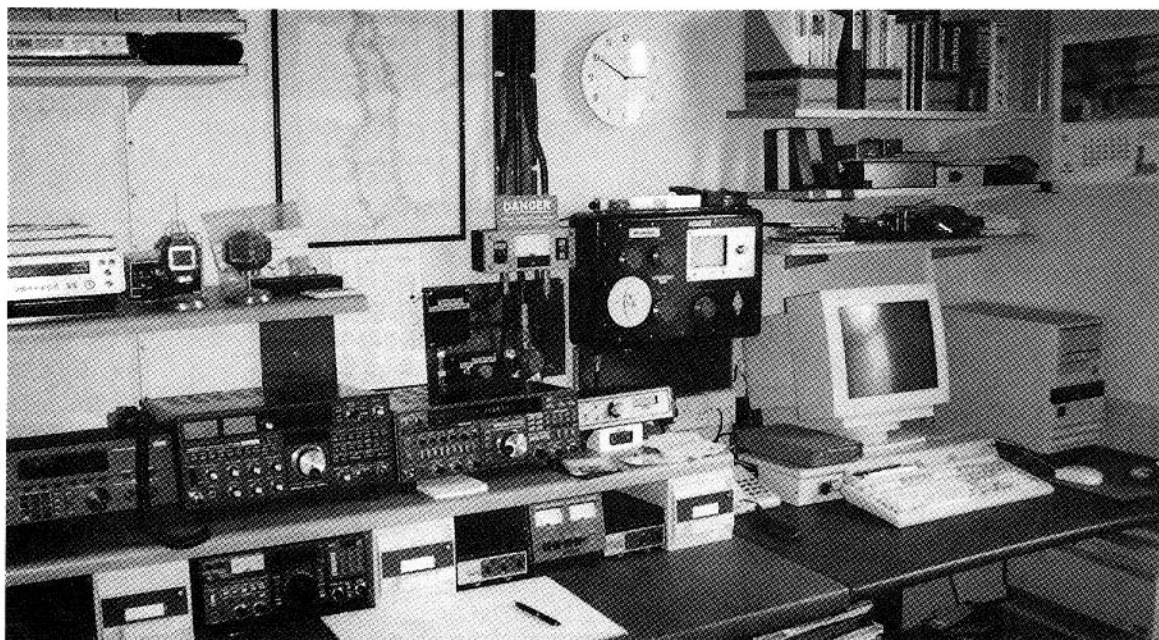
Ron, who is 70 years of age, retired from full time employment after having been in the UK Lighthouse service for 39 years where he headed the Communication Branch which is responsible for installing and maintaining radar and radio marine navigation aids. He has served in the UK and International amateur radio scene in official positions at Club, National Society (RSGB) and IARU level since 1945, when he was part-founder and member of the Marsworth Amateur Radio Club, with Brian Rix, now Lord Rix, while they were in the RAF together.

Ron's involvement with satellites began in 1977 when he was asked to do "a small job



Ron Broadbent, G3AAJ, Order of the British Empire at Buckingham Palace,

of work" for the then new AMSAT-UK. Oscar 6 and 7 were his first satellites when he began the job of sending out the Orbital Calendar from G3IOR. He later became Editor of Oscar News, Secretary and Treasurer of AMSAT-UK in 1978. Presently Ron is the Hon. Secretary/Treasurer/Editor of AMSAT-UK where he devotes about eight hours to this position every day of the week including weekends. He also runs the Sunday and Monday 80 meter weekly Nets. In January of this year, Ron was made a Vice (Life) President of the Radio Society of Great Britain.



G3AAJ has one of the better shacks in the neighborhood. (Jack Colson, W3TMZ photo)

THE WORLD WIDE WEB AMATEUR SATELLITE GROUND STATION

by

Steven R. Bible, N7HPR

n7hpr@amsat.org

How do you introduce potential users to amateur radio satellites? For an individual, you could recommend a good book or two on the subject or you could even invite them over to your shack for a demonstration. Meanwhile you can make a slide or video presentation for groups. However, what happens if you are an individual trying to learn about satellite communications and you cannot find a nearby Elmer? What if you could learn how to set up your own satellite ground station from the Internet? Better yet, what if you could operate a satellite ground station remotely via the Internet?

Announcing the first World Wide Web (WWW) Satellite Ground Station. The URL is:

<http://www.sp.nps.navy.mil/gndstn>

Users with access to the Internet and a Web Browser such as Mosaic or Netscape can use the above URL address to read messages or downloaded and decoded telemetry from the digital satellites UO-22, KO-23, and KO-25. They can also learn about constructing a ground station through a series of WWW pages that include detailed pictures. From these WWW pages you can get a glimpse of what it is like to operate the digital satellites in advance of constructing your own ground station.

Since January 1995, I have been slowly putting together the pieces of a WWW Amateur Satellite Ground Station with the challenge of interfacing a live satellite ground station to the WWW that would allow users to feel like they are operating an actual ground station. On April 11, 1995, general access to the WWW Ground Station was announced on the AMSAT bulletin board. On April 12, a flood of over 2,100 log-ons caused the server and networking software to overload and crash several times. Certainly, there would have been many more log-ons if the software was more stable at the time. Fortunately, since that date, most of the log-on problems have been resolved resulting in more reliable user access to the WWW

Ground Station. On an average day, WWW Ground Station is accessed 500 times and includes an international audience from Austria, Australia, Canada, Czech Republic, Germany, Finland, France, Ireland, Italy, Japan, South Korea, Mexico, Malaysia, Netherlands, Norway, New Zealand, Sweden, Thailand, United Kingdom, and the United States.

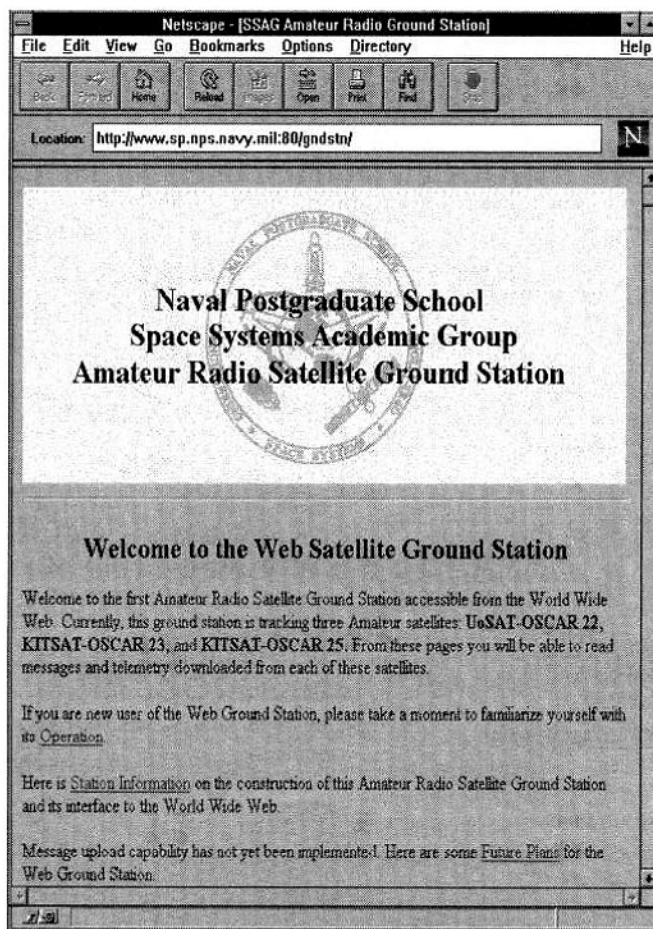
How It All Started

Presently, I am a student at the Naval Postgraduate School (NPS) located in Monterey, California and as a result late last year I became heavily involved with the WWW. In an effort to learn more about WWW and its intricacies, I decided to create WWW pages. My natural instinct was to use Amateur Radio as a vehicle for learning to create WWW pages as it allowed me to learn this new facet of the Internet and at the same time tell others about a fantastic hobby.

My first plunge into WWW was making pages for the Naval Postgraduate School Amateur Radio Club (NPSARC) (see Amateur Radio on the World Wide Web in the June 1995 *QST*). With the help of my friend Greg Pool, WH6DT, and my son Ian, KE4EAC, we proceeded to learn how to format text using Hypertext Markup Language (HTML), the language of WWW. Our goal was to use WWW pages to describe general information about NPSARC and its involvement in the community. We quickly learned it was easy and fun to create and format pages. Little did we know that we were entering the exciting new world of on-line publishing and that the NPSARC WWW pages we crafted would soon be read by a worldwide audience!

My second leg up was to create a WWW server for the Space Systems Academic Group (SSAG) at NPS. From this experience, I learned how to operate the WWW server

software. This was perhaps the most enlightening experience because you can write external "backend" programs using the Common Gateway Interface of the web server allowing other existing programs to be interfaced to the server. For example, you can interface a CD-ROM callbook or a repeater database to WWW.



While browsing WWW, I discovered that Lou Williams, KE4ARM, had written a program to interface a satellite prediction program to WWW. This interface became an important piece leading up to establishing the WWW Ground Station.

My third plunge into WWW was writing the "Spacecraft Information" pages for the AMSAT WWW server that is managed by Paul Williams, KB5MU (see "AMSAT on the World Wide Web," *AMSAT Journal*, Volume 18, No. 1, January/February 1995). This effort resulted in WWW technical pages on past, present, and future amateur satellites.

Building Satellites

SSAG is designing and building an amateur satellite named PANSAT, which stands for Petite Amateur Navy Satellite. A SSAG amateur radio satellite ground station has been constructed with the purpose of familiarizing NPS students on the operation of low earth orbit store-and-forward satellites. The ground station consists of an ICOM IC-970 transceiver, AEA DSP-2232 data controller, 486DX-33 MHz computer, Kansas City Tracker/Tuner, Yaesu G-5400 rotators, and the Cushcraft AOP-1 satellite antennas.

Figure 1 shows the station hardware in a block level diagram.

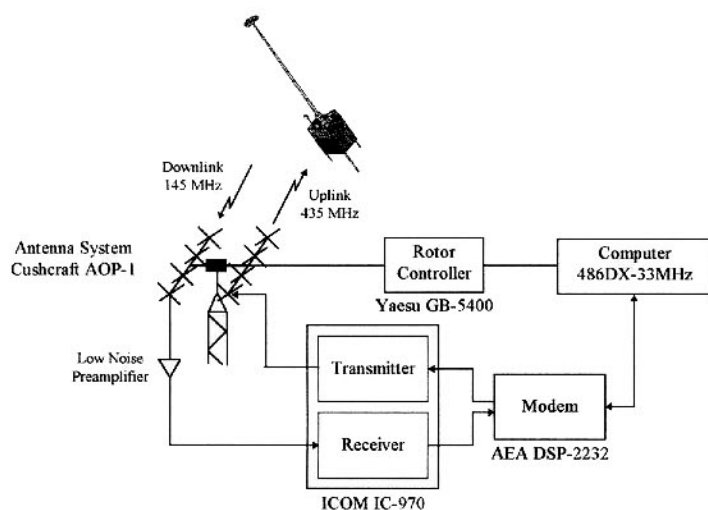


Figure 1. Hardware Block Diagram of the Web Ground Station.

Last summer, Chris Jackson's, ZL2TPO (now G7UPN), Windows Satellite Programs (WiSP) tracking software and David Hoatson's, KC6WYG, Windows KCT/T Driver became available allowing an

unattended ground station to track multiple satellites 24 hours a day. As a result, the second important piece of the WWW Ground Station puzzle was successfully in place.

The final piece of the WWW Ground Station puzzle was to interface the WWW server software with WiSP. To accomplish this, it was necessary to write backend programs to convert files written to the hard drive by WiSP into HTML, the computer language that a WWW browser understands. Two computer programs, PFH2HTML and TLM were written. PFH2HTML reads directory files while TLM reads telemetry files. As a result, here's how it all works:

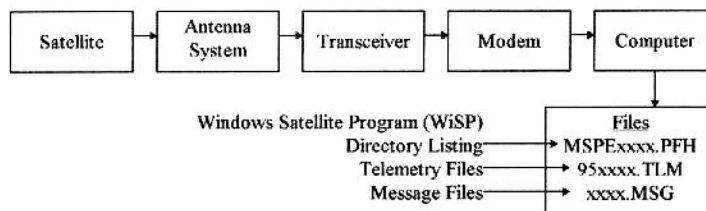


Figure 2. Satellite Information Flow

When a message is uploaded to the satellite, the PACSAT File Header is removed and the message is placed into the satellite's directory. The message is then assigned a sequential hexadecimal number and stored in memory. Ground stations receive directory information from the satellite, scan it for messages that meet downloading criteria, and then request transmission of the messages. The ground station scans the directory and determines if there are any messages are destined for it. If any of the messages are to the callsign of the station or addressed to ALL, the ground station transmits to the satellite to signal it to transmit the message.

The directory listings downloaded from the digital satellites are then placed into their respective satellite directories by WiSP. These directory listings have the filename MSPExxxx.PFH. The prefix MSPE stands for the Microsat Protocol Engine, the program responsible for downloading and decoding information from the satellite. The xxxx is a sequential number assigned by WiSP. The PFH extension identifies the file as written in the Pacsat File Header format. The MSPExxxx.PFH file is a binary file, therefore, it must be read and parsed in accordance with the PACSAT file header protocol.

Linking to Space

PFH2HTML, one of the two developed programs, reads the MSPExxxx.PFH file, parses it, and writes a text file in HTML format. As a result, Internet users operating a WWW browser can read the directory listing from the satellite. However, there was one interesting obstacle to overcome as not all messages or files are downloaded to the ground station. The goal was for a user to read

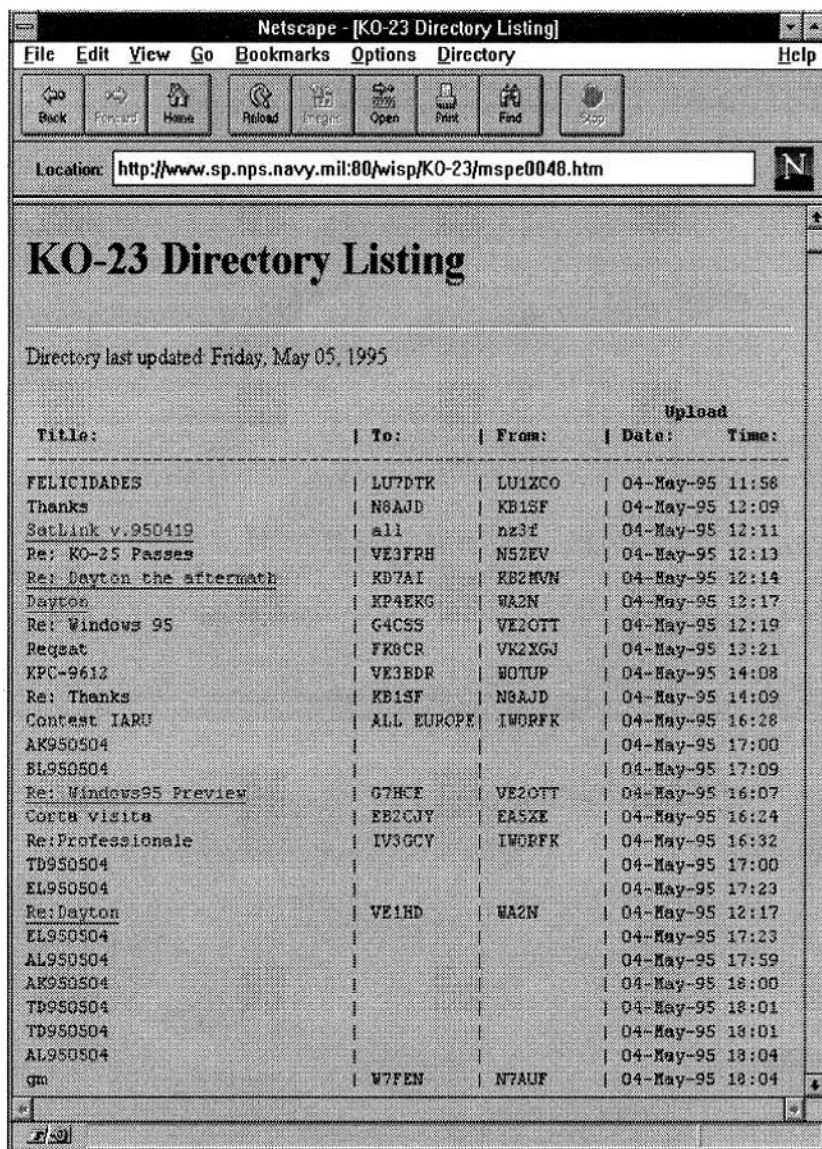


Figure 3. The KO-23 directory listing. Hypertext indicated messages that are available to read

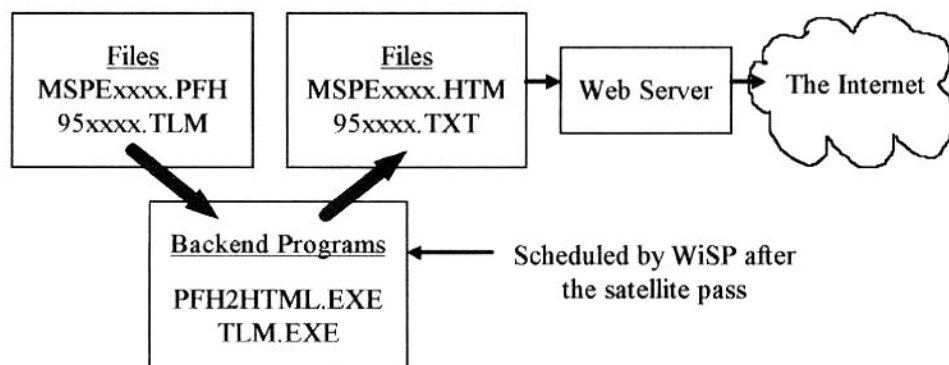


Figure 4. Web Server Information Flow

the messages that have been downloaded and stored on the ground station computer.

One of WWW's powers is in its use of hyperlinks. As a result, PFH2HTML is parsing the directory file and converting the directory listing it checks to see if that message resides on the message directory on the hard drive. If it is resident then PFH2HTML creates a hyperlink (indicated by underlines in **Figure 3**) to the message. If the message is not on the ground station then it is listed in plain text allowing the user to glance at which messages are available to be read by the hyperlink. This elegant interface provides a fantastic demonstration of the power of WWW hyperlinks as it is intuitive, easy to use, and it does not distract the user.

Telemetry files are converted in the same fashion as the directory listings. The second program written, called TLM, reads the raw telemetry and writes a text file in HTML format. The user can choose to read the decoded telemetry or download the raw telemetry for later decoding with his own program.

The beauty of the WWW Ground Station lies in its ability to do all of this unattended. The WWW Ground Station tracks individual satellites and downloads directory listings, messages, and telemetry. WiSP tracks the satellites and places the files into their appropriate directories while the programs PFH2HTML and TLM convert the files into HTML format for the Web (see **Figure 4**). But the backend programs could not do their job if it were not for WiSP's unique feature of scheduling programs. PFH2HTML and TLM are scheduled to run two minutes after the satellite pass allowing files to be kept up to date. Anytime a user comes to browse the Web Ground Station they are viewing the latest files available from the station's location.

Needless to say, the PFH2HTML and TLM were not trivial programs to write. A technique called "code reuse" was used which means someone else's source code was borrowed and modified for the WWW Ground Station. John Melton, G0ORX/N6LYT, wrote a series of microsat programs for the Linux operating system and released the source code through the GNU General Public License

making it freely available. If it were not for John's generosity I would not have had the time or the detailed knowledge to complete the Web Ground Station. Thanks John!

From Programming to Praise

What has kept me going throughout this project is all of the praise I have received via email. All of it completely unsolicited. Here are some samples and they have been edited for brevity but in no way were altered:

What an incredible effort you have made with this. You have given the non-space type hams a really good look at what it is like on the digital birds. - Mark Hammond, KC4EBR

What a neat idea. Now I can just save electricity and not have to run my satellite station. - Ron Parsons, W5RKN

This is a fantastic display of current technology! Well done! You just became my favorite "cool stuff" to show my users the capability of the Web and Ham radio. Everyone will want to see this. - John Schweiger, N8YAU

GREAT JOB! It seems real good to show new guys what its all about. Your spectacular full color introduction is likely to get more people interested and I think their next logical question is what birds and frequencies? Congratulations again and keep up the great work. - Kevin Bierney, N6CWF

What a great way to get the satellites into our classrooms!! We will use it a lot. Good luck on the installation. - Dave Reeves, KF6PJ/WA6BYE

You have really done something new; what never has been done before. Many hams (or even non-radio amateurs) will be able to see what radio amateurs and amateur radio satellites can do or are capable to do...congratulations to your brilliant idea and you can be sure that I will look into your Web Satellite Ground Station from time to time. - Peter Guelzow, DB2OS

BRILLIANT!!! - James Miller, G3RUH

Summary

The WWW Ground Station has been a resounding success. WWW interface using hypertext as the method of accessing messages and telemetry is easy to use, intuitive, and it provides a glimpse into the world of low earth orbiting digital store-and-forward satellites. There are also pages explaining the ground station for those interested in constructing their own. I have received several email messages expressing delight and wonderment at the creation of the WWW Ground Station. There have also been many congratulatory messages. These have helped me realize that the design of the ground station is good. In addition, the messages have sustained and motivated me to improve and maintain the WWW Ground Station for all who desire to visit. I sincerely believe that I have met the goal of providing a service for the inquisitive and the seasoned amateur and non-amateur alike. Hopefully, the WWW Ground Station will successfully prove to be a new window that will introduce people to the exciting world of amateur space communications.

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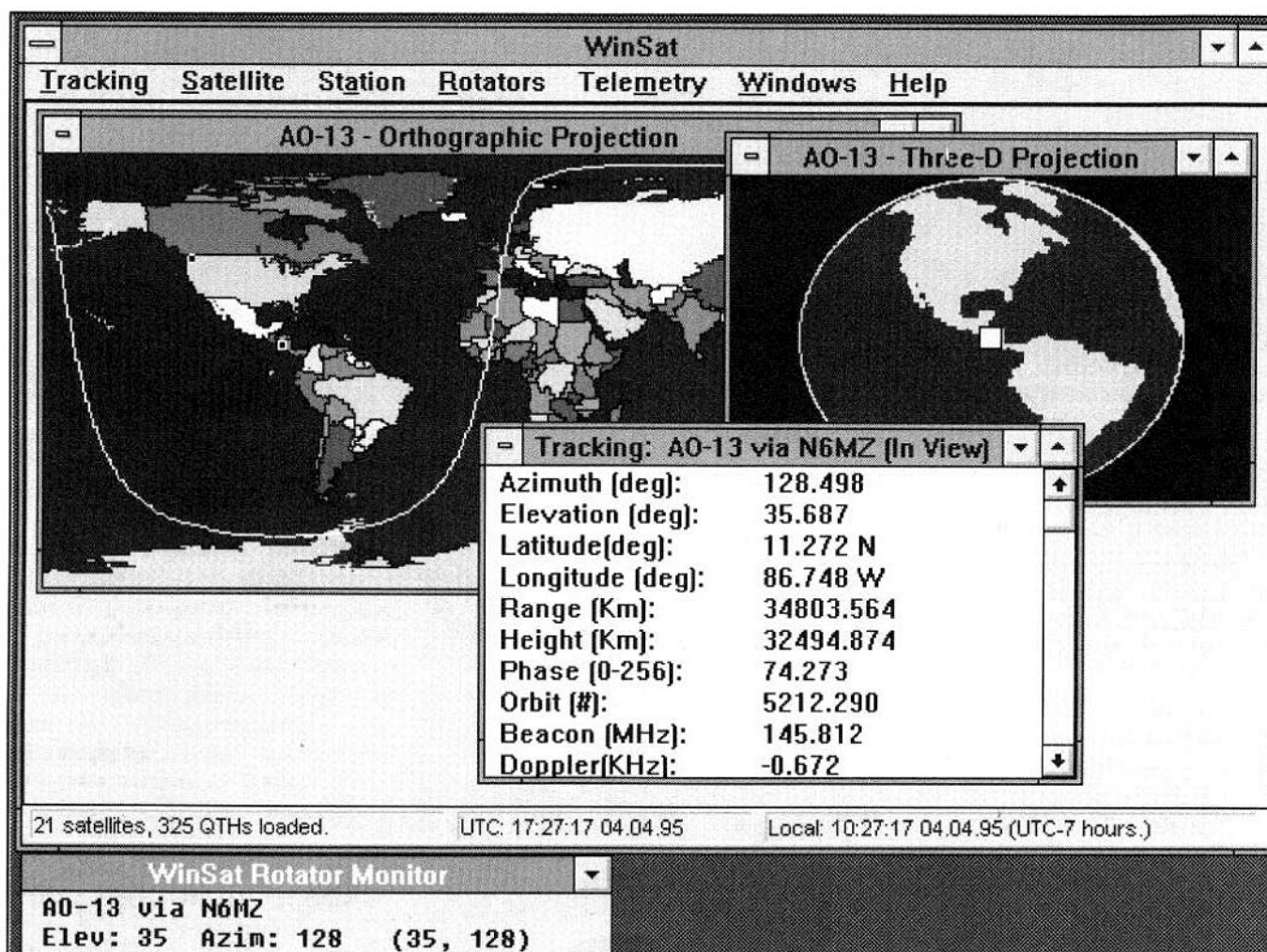
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To install WinSat:

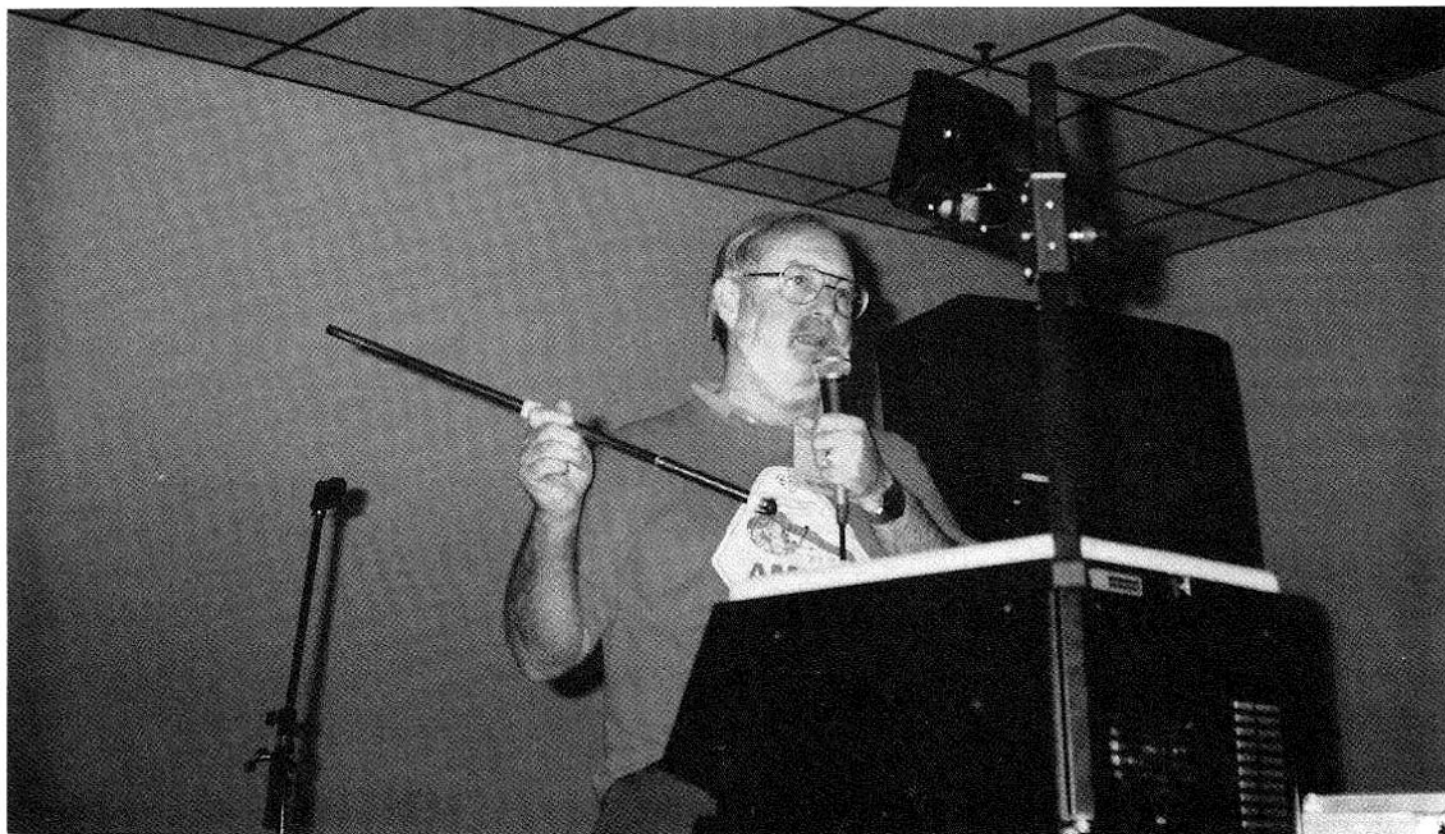
- 1 Insert the WinSat diskette in your A or B: drive.
- 2 Go to the Windows Program Manager and choose the File: Run command.
- 3 Type the following in the box: A:\WinSat or B:\WinSat
- 4 Choose the OK button.

The recommended minimum machine requirements for WinSat are:

- 386/25MHz CPU with math coprocessor
- VGA or higher, or compatible display
- Microsoft Windows 3.1 or higher
- Hard disk with at least 2Mbyte free space

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ANOTHER BANNER YEAR FOR AMSAT AT DAYTON



Lou McFadin, W5DID, recently appointed Phase-3D Integration Manager, displays some of his handiwork...the flight demonstration model of Phase 3-D's torquing rod system. The unit was the first of twelve others that he later built in his garage workshop for the project. (KB1SF photo)

By Keith Baker, KB1SF, Executive Vice President

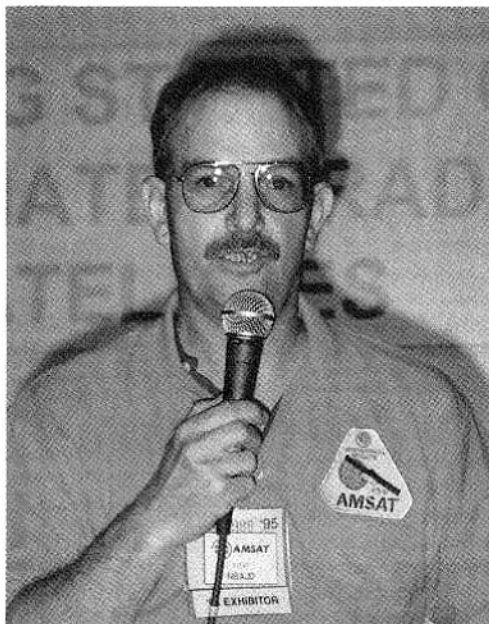
Good weather, good attendance, and increased interest in satellite activities all combined to make this one of the best years yet for AMSAT at the Dayton Hamvention.

While preliminary reports pegged the overall Hamvention attendance down just a bit from past years, still, nearly 34,000 Hams from around the world descended on Hara Arena on April 28-30, 1995 for the annual event.

AMSAT's strong presence at this year's Hamvention actually began well before the Hamvention got underway when Bill Tynan, W3XO, AMSAT-NA President, and Keith Baker, KB1SF, AMSAT-NA Executive Vice President, addressed the Amateur Radio Industry Group (ARIG) on Thursday evening, April 27th. The ARIG is composed of Amateur Radio equipment manufacturers, dealers and vendors as well as those who provide media publications

and other services to the Amateur Radio hobby. AMSAT was invited to the gathering to highlight ongoing progress on the Phase

3-D project, particularly with regard to its proposed operating frequencies and modes. The theme of Bill's and Keith's remarks was to encourage members of ARIG to begin planning for Phase 3-D's eventual launch in 1996. Specifically, they passed out fliers listing Phase 3-D's final operating frequencies and modes and then went on to encourage members of the industry group to design and manufacture additional pieces of low-priced equipment that would exploit P3-D's new bands and modes. The presentation was well received by all ARIG members present.



Steve Grant, N8AJD, Southern Ohio AMSAT Area Coordinator, gives newcomers some operating tips at the Beginner Forum (KB1SF photo)

Friday dawned a sunny and relatively warm day and the crowds were out in force early, visiting the over 4500 outdoor flea market spaces as well as the over 650 indoor vendor booths. As in past years, AMSAT was located in booths 445-448 in the Ball Arena area of Hara. Mike Crisler, AMSAT-NA VP

Field Operations, skillfully led a team of over 20 volunteers at our booth. New offerings this year included a brand new book by Ed Krome, KA9LNV, on Mode S operating; a newly updated Fifth Edition of "How to Use the Amateur Radio Satellites" by Keith Baker, as well as an updated version of WINSAT (now supporting



Rosalie White, WA1STO, ARRL Educational Activities Manager, a key member in the SAREX working group, proudly accepts the Hamvention "Ham of the Year" award from the 1995 Hamvention General Chairman Ken Allen, KB8KE. (KB1SF photo)

the Kansas City Tracker, mutual DX window, satellite ephemeris, and AO-13 telemetry capture) by Joe Holman, KA7LDN. Other new "goodies" included brand new Phase 3-D caps and shirts sporting the P-3D logo on the front as well as a newly updated laminated frequency chart. P3-D caps and shirts will be available in the coming months at selected AMSAT hamfest booths. The other new items are available now from AMSAT-HQ.

Friday's AMSAT forum was hosted by Keith Pugh, W5IU, AMSAT VP, Operations, and featured Frank Bauer, KA3HDO, Rosalie White, WA1STO, and Matt Bordelon, KC5BTL, who collectively presented an outstanding SAREX forum. One highlight of the forum was a direct telephone hookup with Ron Parise, WA4SIR, who talked about his recent Shuttle mission

and who also answered questions from the forum audience. Steve Grant, N8AJD, AMSAT's Southern Ohio Area Coordinator rounded out the Friday forums with a superb talk on how to get started on the analog and packet satellites. On Friday evening, nearly 70 AMSATers attended the traditional AMSAT dinner at Dayton's Stockyards Inn.



Frank Bauer, KA3HDO, hosts SAREX forum that also featured a live telephone hookup with Shuttle astronaut Ron Parise, WA4SIR. (KB1SF photo)

Saturday's weather was a repeat of Friday's and an even bigger crowd jammed Hara where AMSAT's booth business again was brisk. Later, AMSAT President Bill Tynan hosted Saturday's forums where Keith Baker and Lou McFadin, W5DID, gave a standing-room-only crowd of about 500 the latest details on Phase 3-D. Ed Krome then gave his ever-popular Mode S talk to a crowd nearly as large in the same room.

At Saturday evening's gala banquet, Rosalie White, ARRL Educational Activities Manager (and key member of the SAREX working group) garnered the Hamvention's highest honor by receiving their prestigious "Ham of the Year" award. Much later, and back at the hotel, Glenn Moody, N4OUL, was honored by his fellow PACSAT operators at their annual "FUBAR-fest" for his outstanding work in getting newcomers up and running on the packet birds.

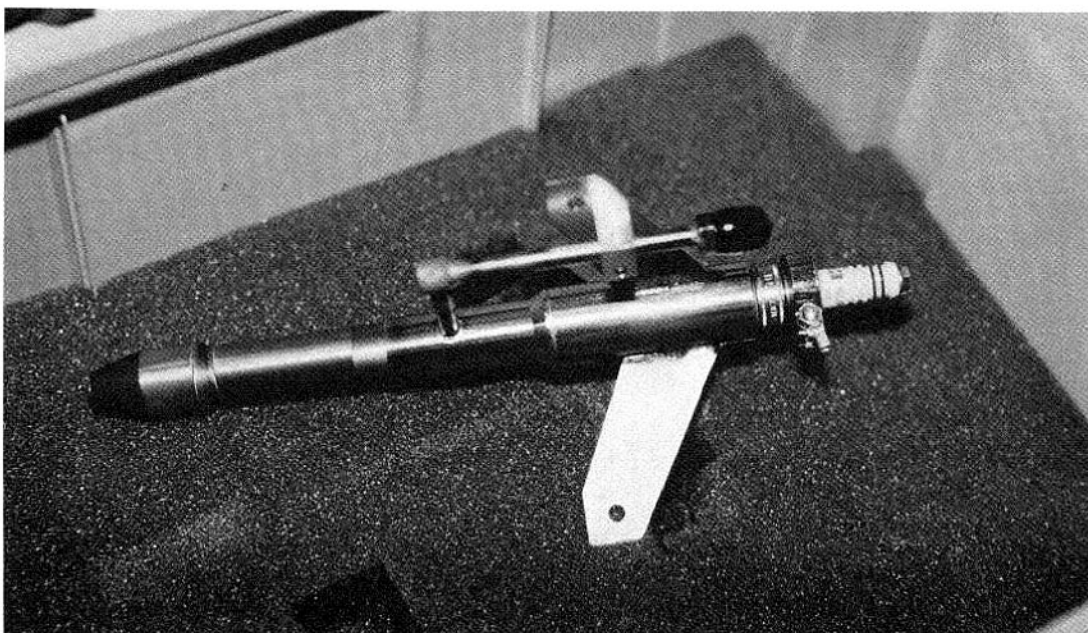
All-in-all, it was another highly successful year for AMSAT at Hamvention, and plans are already being formulated for an even bigger AMSAT presence at next year's event. Our sincere thanks to those whose individual hard work made it all happen for us in 1995. Remember, next year Hamvention dates change to May 17th, 18th and 19th.



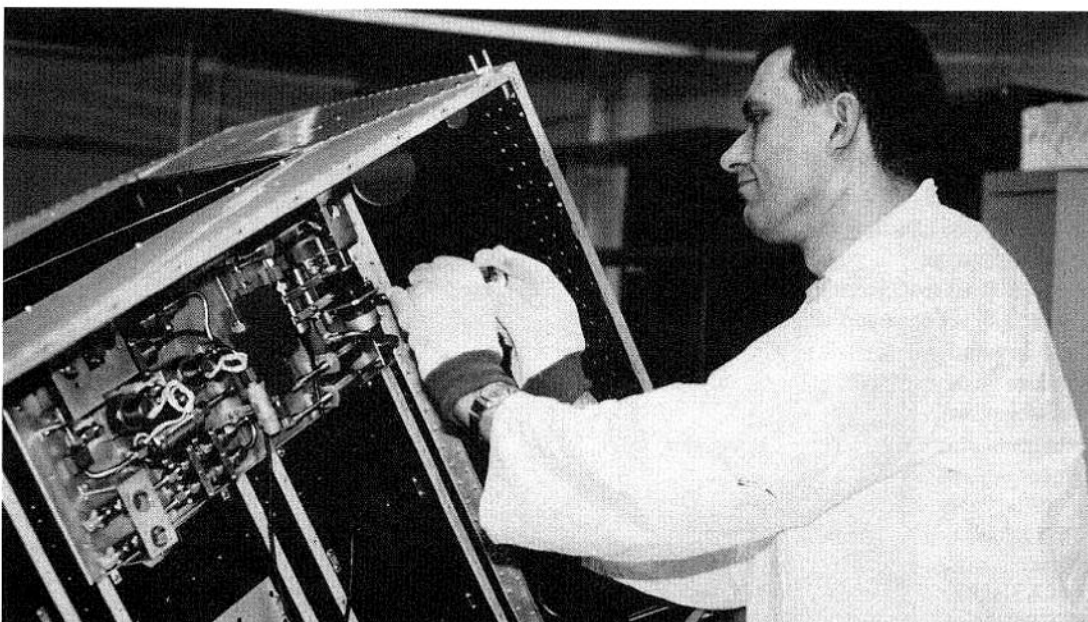
Some of the standing-room-only crowd of nearly 500 who got the latest details on Phase 3-D at Saturday's AMSAT forum. (KB1SF photo)

In all the world, there is only ONE Dayton Hamvention, and the 1995 version was no exception! Start making your plans NOW to attend in 1996. See you then! ■

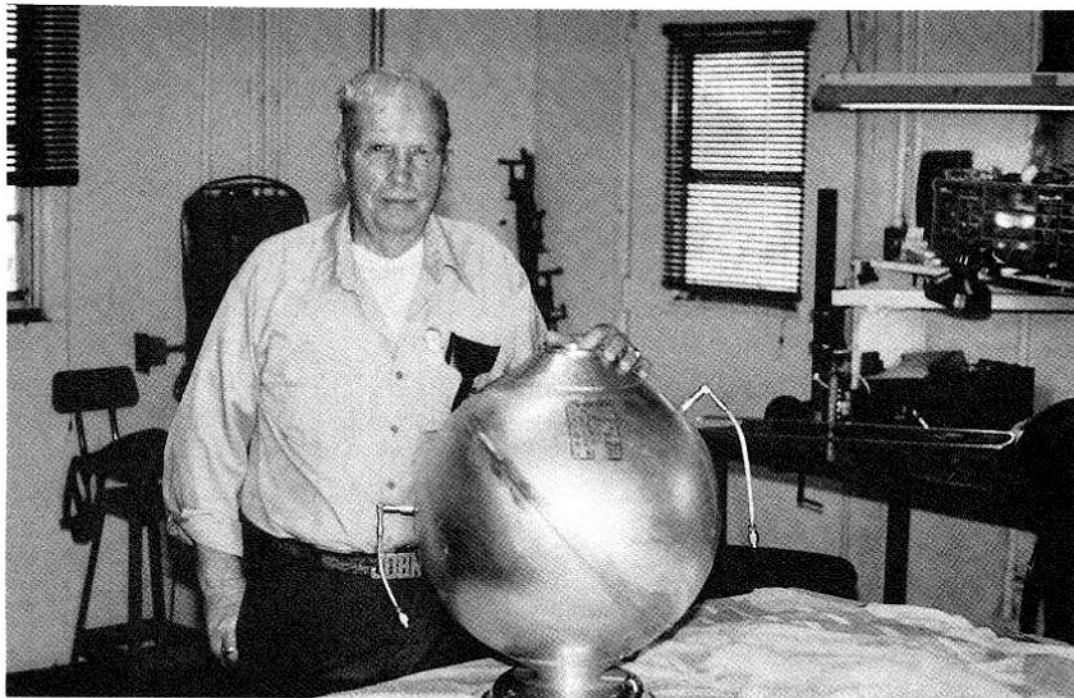
Phase 3D DEVELOPMENTS



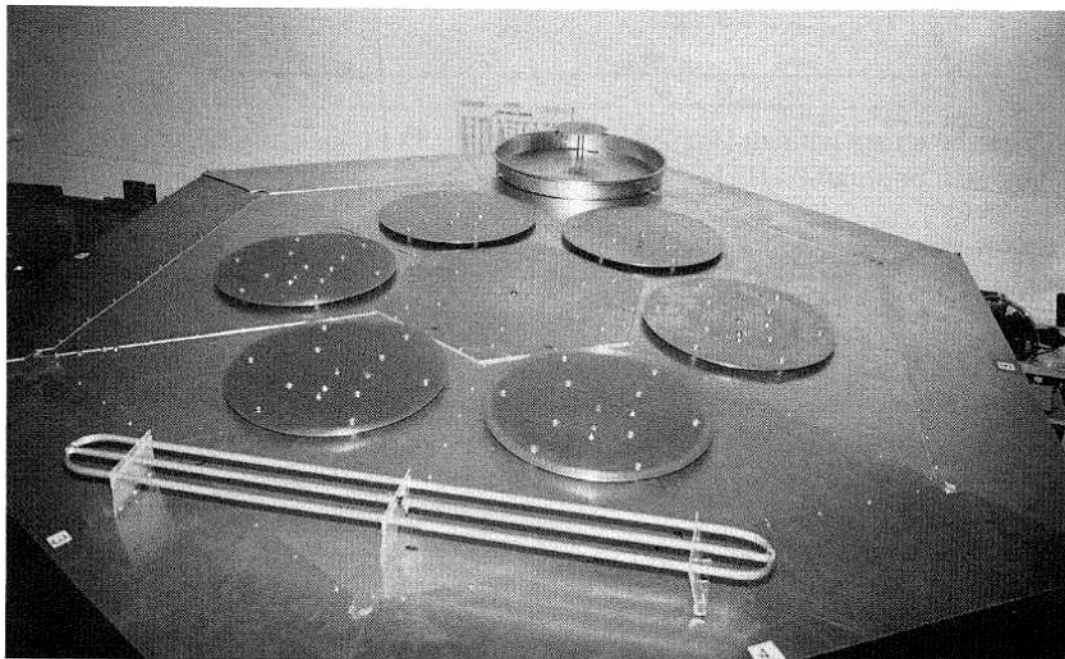
An arc-jet flight model will allow long-term capability to perform Phase 3D minor orbit adjustments. Using an ordinary automobile spark plug, the arc-jet expands gaseous ammonia by heating it to a very high temperature. A small amount of thrust is then produced when the gas escapes from the motor's small nozzle. (AMSAT-NA photo by Dick Daniels, W4PUJ)



Dr. Dieter Zube installs a portion of the Phase 3D flight model Propellant Flow Assembly (PFA) into a spacecraft. The PFA will control both the flow of hypergolic propellants to the Phase 3D's 400 Newton kick motor as well as the flow of ammonia to the satellite arc jet positioning motor. The kick motor will be used to place Phase 3D into its final orbit. (KB1SF photo)



John Darbyson, WB4MOX, shows his work after welding fittings to the propellant tank. John and his wife have volunteered their welding services to Phase 3D. (AMSAT-NA photo by Dick Daniels)



A full-scale mockup of Phase 3D's top panel has been constructed for testing antennae without disturbing ongoing spacecraft integration efforts. Here, one of three V-band dipoles, as well as the U-band patch array and L-band short backfire antennae are clearly visible on the mockup. (AMSAT-NA photo by Keith Baker, KB1SF)

Current Amateur Satellite Frequencies

Satellite	Callsign	Uplink (MHz)	Downlink (MHz)	Type
AO-10		435.03-435.18 LSB/CW	145.975-145.825 USB/CW	Mode B Analog
AO-13		435.423-435.573 LSB/CW	145.975-145.825 USB/CW	Mode B Analog
AO-13		435.603-435.639 USB/CW	2400.711-2400.749 USB/CW	Mode S Analog
FO-20		145.9-146.0 LSB/CW	435.9-435.8	Mode J Analog
AO-27		145.85 FM	436.80 FM	Part-Time Repeater
RS-10		145.865-145.905 USB/CW	29.360-29.400	Mode A Analog
RS-12		21.21-21.25 USB/CW	29.41-29.4	Mode K Analog
RS-15		145.858-145.898 USB/CW	29.354-29.394	Mode A Analog
AO-16	PACSAT	145.90, .92, .94, .96 FM	437.0513 SSB	1200 Baud PSK
DO-17			145.825 FM	1200 Baud AFSK/Voice
WO-18			437.104 SSB	1200 Baud PSK (img)
LO-19	LUSAT	145.84, .86, .88, .90 FM	437.1258 SSB	1200 Baud PSK
FO-20	8J1JBS	145.85, .87, .89, .91 FM	435.91 SSB	1200 Baud PSK
UO-22	UOSAT5	145.9, .975 FM	435.12 FM	9600 Baud FSK
KO-23	HL01	145.85, .90 FM	435.175 FM	9600 Baud FSK
KO-25	HL02	145.87 FM	436.5 FM	9600 Baud FSK
IO-26	ITMSAT	145.875, .90, .925, .95 FM	435.822 SSB	1200 Baud PSK
POSAT	POSAT1	145.975 FM	435.2777 FM	9600 Baud FSK

1) Frequencies shown are without Doppler compensation. For typical digital satellite pass, the original signal will be about 8 kHz higher than what is shown.

2) WO-18 Webersat transmits experimental and image data and can be captured in KISS mode via PB or TLMDC.

3) Except for FO-20, the digital satellites use a program suite containing PB/PG/PFHADD/PHS or WiSP. The broadcast callsign (in PB.CFG) is the satellite's callsign with an SSID of -11. The connect mode callsign (in PG.CFG) is the satellite's callsign with an SSID of -12.

4) When in mode JD, FO-20 can be worked with any packet program. Connect to 8J1JBS. FO-20 currently alternates between modes JA and JD on a weekly basis. Consult ANS for schedule.

5) AO-10 is no longer controllable but the transponder works when the satellite is in sunlight.

6) For AO-10 and AO-13, transmit LSB, receive USB. As transmitted frequency is increased the received frequency will decrease (inverting transponder).

The Re-Entry of OSCAR-13

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 Proceedings of the AMSAT-NA 12th Space
 Symposium, Orlando, FL, October 7, 1994.*

Without an atmosphere, Oscar-13 would collide with the Earth's crust on February 3, 1997. But we do have an atmosphere, which means that the satellite experiences a gradual retardation every perigee pass. Thus re-entry will be sooner, approximately December 5, 1996. This paper outlines the computer program used and discusses the circumstances.

Satellites such as Oscar-13 that are in orbits which take them a long way (10,000 km) from the Earth experience significant forces from the Sun and Moon. This causes the

orbit shape and orientation to oscillate slightly, with periods measured in years.

Geostationary satellites have on-board thrusters to compensate for these inescapable deviations. But Oscar-13 does not, and its orbital eccentricity is now (1994) monotonically increasing, with an attendant decrease in the height of perigee. When this height reaches a little under 200 km, atmospheric drag becomes significant, converting the satellite's energy into heat and slowing it down.

Satellite Orbital Elements

by Ray Hoad, WA5QGD

Satellite	AO-10	UO-11	RS-10/11	AO-13	FO-20	RS-12/13	RS-15
Catalog Number	14129	14781	18129	19216	20480	21089	23439
Epoch Time	95130.3571897	95136.0431580	95138.0135371	95135.1170453	95136.7541936	95136.4552508	95136.8385227
Element Set	351	798	67	38	792	799	50
Inclination	26.4892	97.7825	82.9250	57.5427	99.0710	82.9206	64.8200
RA of Node	268.9371	140.0896	81.3717	187.4499	231.1985	124.3134	305.6906
Eccentricity	0.6005645	0.0010811	0.0011531	0.7289897	0.0540459	0.0027353	0.0167640
Arg of Perigee	275.5410	288.8939	167.8566	8.9363	304.4834	261.8949	267.7982
Mean Anomaly	22.9393	71.1090	192.2867	359.2652	50.6330	97.9105	90.3741
Mean Motion	2.05881648	14.69342463	13.72352236	2.09724770	12.83229532	13.74057315	11.27523562
Decay Rate	-.00000442	.00000183	.00000034	-.00000236	-.00000022	.00000039	-.00000039
Epoch Rev	8952	59918	39583	5296	24691	21441	1598
Satellite	UO-14	AO-16	DO-17	WO-18	LO-19	UO-22	KO-23
Catalog Number	20437	20439	20440	20441	20442	21575	22077
Epoch Time	95136.2436805	95136.7764616	95137.2578125	95136.7496928	95136.7747561	95137.1616704	95137.8016856
Element Set	97	896	896	900	896	602	493
Inclination	98.5676	98.5787	98.5799	98.5800	98.5814	98.3981	66.0881
RA of Node	221.1279	223.2759	224.2000	223.6743	224.0501	209.2468	299.3896
Eccentricity	0.0010161	0.0011193	0.0010849	0.0011530	0.0011839	0.0008496	0.0008625
Arg of Perigee	295.2161	296.0432	292.6115	295.2348	294.3346	17.7574	205.6569
Mean Anomaly	64.7995	63.9597	67.3880	64.7637	65.6598	342.3904	154.4021
Mean Motion	14.29886837	14.29940463	14.30080896	14.30052339	14.30154560	14.36974883	12.86291415
Decay Rate	.00000101	.00000061	.00000009	-.00000001	.00000025	.00000032	-.00000037
Epoch Rev	27718	27727	27736	27729	27731	20104	12982
Satellite	AO-27	IO-26	KO-25	MET-3/3	NOAA-14	MIR	HUBBLE
Catalog Number	22825	22826	22828	20305	23455	16609	20580
Epoch Time	95137.1929273	95137.2192645	95137.6429873	95137.8095670	95137.6918262	95137.1349805	95134.4888209
Element Set	391	390	368	314	179	38	664
Inclination	98.6186	98.6195	98.6153	82.5508	98.8987	51.6485	28.4739
RA of Node	214.0372	214.1542	214.6071	38.6387	80.4471	313.0730	267.4602
Eccentricity	0.0008567	0.0008980	0.0009722	0.0006705	0.0008951	0.0004156	0.0006747
Arg of Perigee	318.5958	319.2084	301.2139	189.3922	286.9156	313.8430	320.6930
Mean Anomaly	41.4577	40.8419	58.8090	170.7087	73.1030	76.4998	39.3098
Mean Motion	14.27661720	14.27769110	14.28099258	13.04423825	14.11510554	15.56531870	14.90874578
Decay Rate	.00000005	.00000001	.00000042	.00000044	.00000037	.00004976	.00000591
Epoch Rev	8534	8535	5351	26652	1951	52811	7887

Thus each subsequent apogee is slightly lower and gradually the orbit circularizes. Mean motion increases, and finally the friction is so great that the orbit goes parabolic and the satellite plunges, burning up as it re-enters.

Somewhat prior to that of course, it will have overheated, and the electronics will certainly fail before burn-up.

Modelling

The numerical methods used for this study are outlined in [2] *May the Force be with You*, which should be studied. That paper also contains a bibliography of all amateur work in this field up to December 1992, and these references are repeated here.

Briefly, integration of the 3-dimensional equations of motion by both direct (Cowell) and Encke's method have been used. The results here use direct integration by a Runge-Kutta-Nystrom 6th order (RKN6) algorithm.

Forces modelled are Earth's gravity plus bulge terms J2, J3 and J4, the Sun and Moon, and atmospheric drag. Drag depends on the atmosphere's density, and the model documented in [1] chapter 4.4 and appendix L.3 is implemented.

The integration step size varies from approximately 100 sec at perigee to 1800 sec at apogee. At each apogee a set of osculating (kissing) Keplerian elements is dumped to disc for later analysis. The program stops when the orbit goes parabolic, i.e. eccentricity 0.

The program is written in BASIC, uses 8-byte floating-point arithmetic and runs uncompiled on an Acorn RISC Computer at a rate of 2.5 seconds computation per orbit, which is about 30 minutes per simulation year. Coding is for clarity, not speed. [The listing is available as part of this archive].

When seeded with post launch keplerian elements, the agreement with subsequent elements over the 6 years to July 1994 is within a fraction of 1 degree, and gives full confidence in predictions for the future (Figure 1).

Drag

This is the retarding force experienced as the satellite collides with gas molecules. It's a function of the frontal area of the satellite, its velocity relative to the revolving atmosphere, and most crucially, the atmosphere's density (kg/m^3).

Figures for the mean density are well documented by many authors. But all

caution that density is a function of several factors, including day/night, time of year, solar activity, sun's rotation, position in 11 year sun-spot cycle and so on. In consequence spot density figures on any particular day can be expected to deviate temporarily from the mean density typically 50% either way.

Clearly then it is important to examine the way Oscar-13's orbit decays with changing density. This can be done coarsely by starting with a reference model as per [1], and then running the program with the density $\times 0.01$, $\times 0.1$, $\times 1$, $\times 10$, $\times 100$ of nominal and observing the changing outcomes.

Drag acts against the direction of motion through the atmosphere. However since the satellite is asymmetric, like an aircraft's wing it will also experience side-thrust. This is called lift. Since it is somewhat difficult to model, is hopefully small and probably averages out to zero over a perigee encounter, it has been ignored. Lift affects the orbit's orientation rather than its shape.

Heating

If the drag force is F_d Newtons, and the satellite's velocity relative to the atmosphere is V_r m/s then it is converting kinetic energy into heat at a rate of $P_{wr} = F_d \cdot V_r$ watts.

Half (say) of this energy is swept away by the gas, the remainder is absorbed by the satellite, which warms up.

Oscar-13 is in comfortable equilibrium with the Sun's incident energy of 500 watts. Clearly then additional heat of (say) 10x more will overheat the satellite, or at least damage the external structure, in particular the solar panels.

So as a rule of thumb, we could expect the satellite to fail through overheating when $P_{wr} = F_d \cdot V_r = 10 \text{ kw}$ or so. This occurs about 3-5 weeks before re-entry.

Study of the peaks however shows them to be short lived, of duration about 100 sec, and with -10dB power points spaced about ± 1.5 minutes. See Figure 2 which shows this for several successive perigees that peak at 10 kW.

About a week before re-entry thermal heating reaches 100kW, and exceeds 400 kW on the last orbits.

Break-up?

The actual drag force is very small. Since from the above, $F_d = P_{wr}/V_r$ the total drag

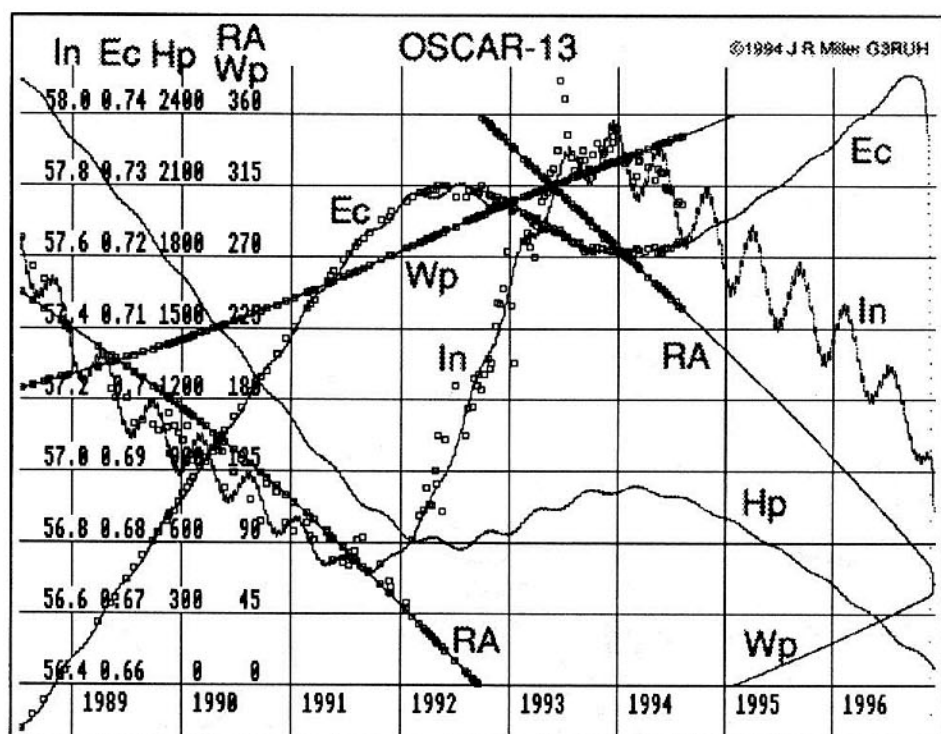


Figure 1. Oscar-13 keplerian elements from launch to re-entry. Superimposed is NASA/Norad data showing close agreement between model and reality. Abbreviations: In = Inclination deg; Ec = Eccentricity; Wp = Argument of Perigee deg; RA = Right ascension of ascending node RAAN deg; Hp = Perigee height km.

at 10 kW heating is $10,000/7,000 = 1.4$ Newtons, equivalent to 0.15 kg weight on Earth. This is unlikely to rip any parts off.

Even on the last fireball orbits, the total drag is less than $400,000/7,000 = 57$ Newtons, equivalent to 6 kg weight on Earth. This force is vastly less than the satellite endured during shake testing, but when parts of it are momentarily melting one must suppose that extremities such as antennas will be swept away during this last week.

Nominal Re-entry Conditions

Figure 3 shows Oscar-13's eccentricity, perigee height and peak frictional heating from 1994 Jul 14 to the end of 1996. This gives a nominal overview of the proceedings.

From the user's point of view nothing will appear to change until about 1996 Oct 10 when peak friction reaches 500 watts which will be noticeable on the perigee telemetry. Transponder performance and satellite visibility should be exactly as they have always been.

Around November 13 peak frictional heating reaches 10 kW, and the satellite will probably fail. Changes in the eccentricity and mean motion will be just perceptible.

Twenty-five days later, on December 8, 1996 the satellite re-enters.

Re-entry with more/less drag

Figure 4 shows the last year of life computed using the nominal drag model, but superimposed with drag scaled up x10 and down 1/10.

In the higher drag case, decay is rather more protracted, with the 500 watt point reached on August 17, 15 weeks before re-entry, the 10 kW "failure" point is around October 28 followed by re-entry 36 days later.

If the drag is 10 times too low, the onset of heating is later, showing 500

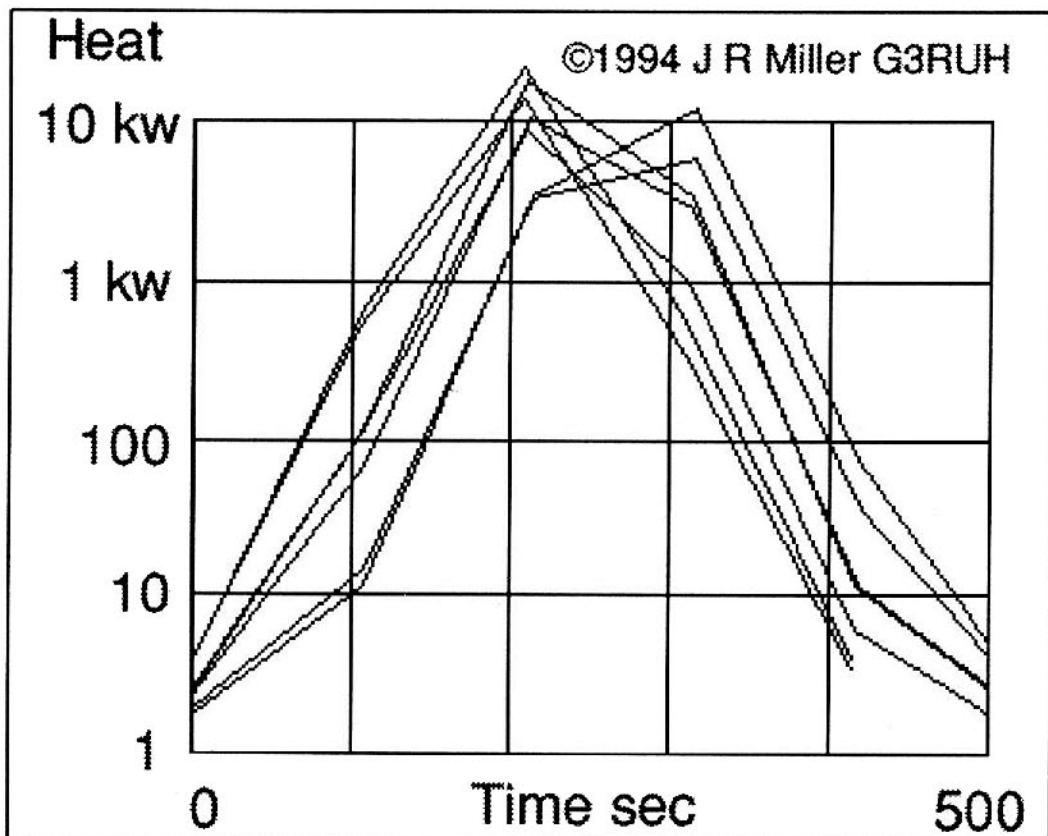


Figure 2. Profile of heating due to friction. Depicts several successive perigees peaking at the 10kW level.

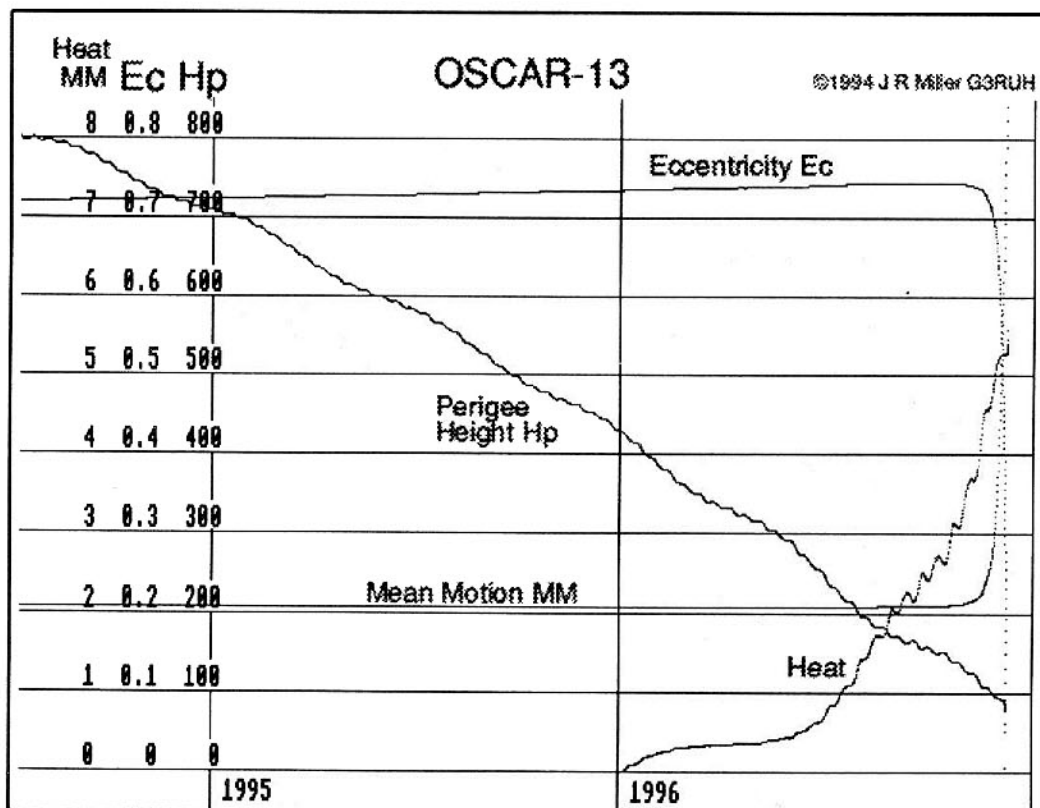


Figure 3. Nominal re-entry conditions. Abbreviations: MM = Mean motion rev/day. Heat shown as Log 10 (power in watts).

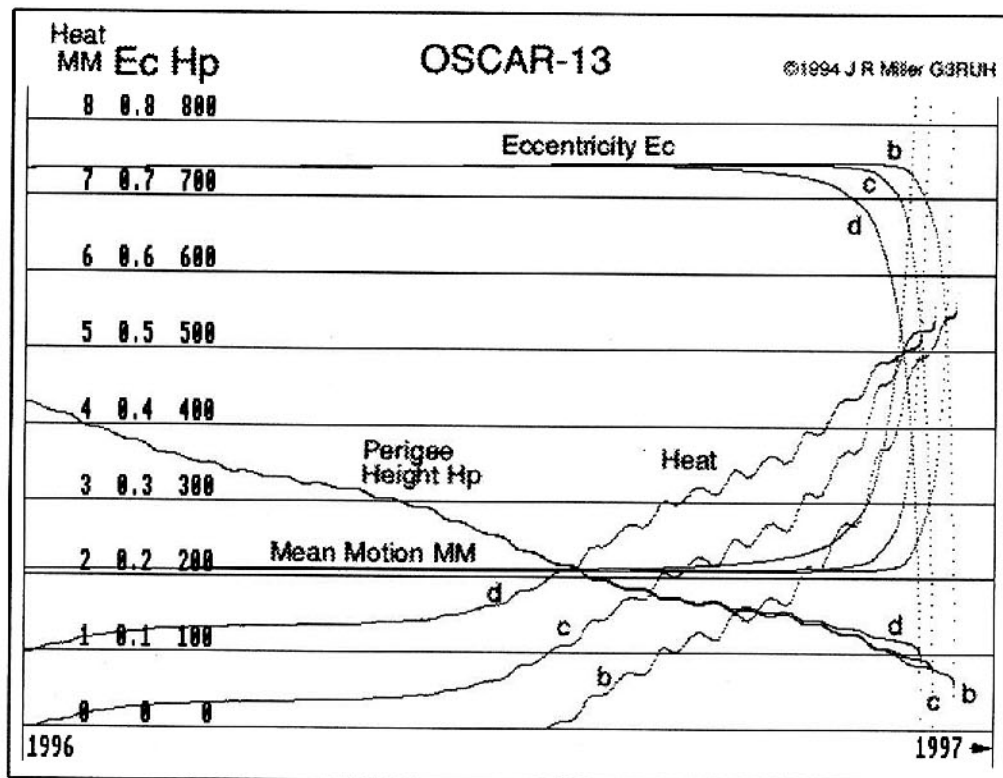


Figure 4. Last year of life with drag model scaled x0.1 (b), x1 (c), x10 (d).

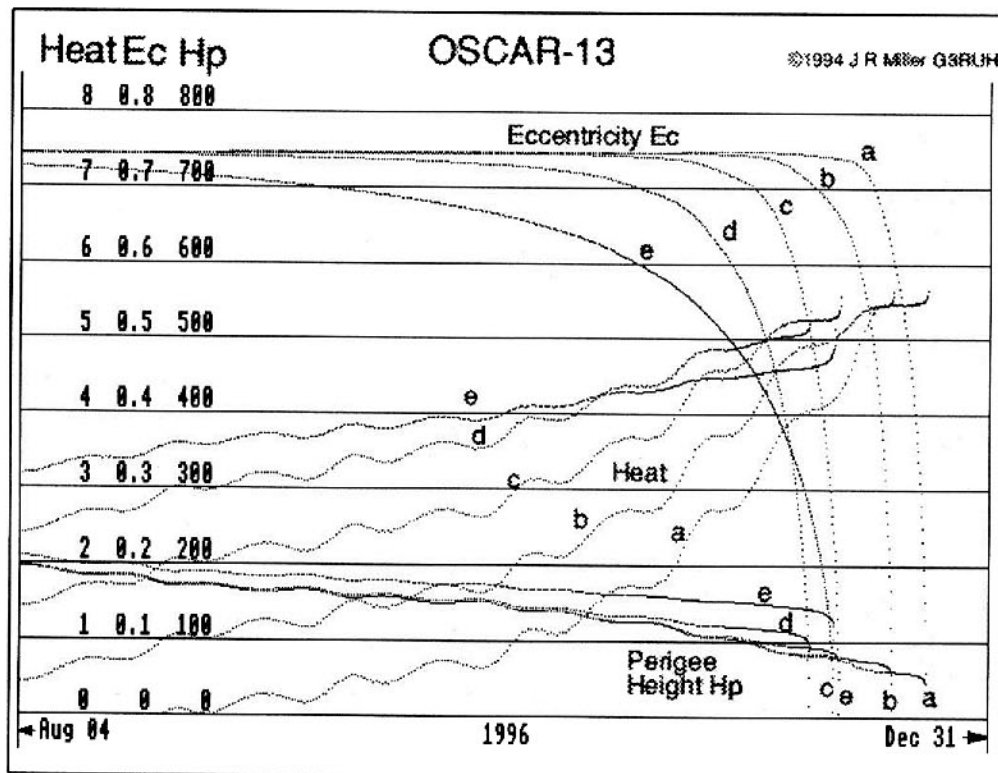


Figure 5. Last 3 months of life with drag model scaled x0.01 (a) to x100 (e).

watts on November 3, 6 weeks before re-entry, rapidly reaching 10 kW on November 24, followed by re-entry just 22 days later.

The spread of re-entry dates here is December 3 -16, 1996.

Even more/less drag

Figure 5 shows the last 3 months life, with a spread of drag scaling from x100 down to 1/100; mean motion is omitted for clarity.

We discover that when the drag is modelled x100 more than nominal, the re-entry date is later than for the x10 case. This is further illustrated in Figure 6. From this the earliest possible re-entry date is December 3, 1996.

Conclusion

The purpose of this paper is to demonstrate that accurate modelling of spacecraft orbits by direct integration of the equations of motion is well within the capabilities of today's personal computers. Readers should not assume that a Cray Vector II (TM) is required! Far from it. In fact this work was started in December 1987 in 5 byte floating point interpreted BASIC on a 64K 6502 machine running at 3 MHz, and achieved comparable results in "overnight" runs.

Today's hardware and software is perhaps 100x faster than that, and allows very long term analyses as well as "what-if" situations to be studied rapidly. For example, all the runs and re-runs presented in this report, plus the text, were generated in just a couple of days work.

The program listing is available on request from the author via Internet, and will be seen to be very straightforward and non-mysterious. It will allow many more people to study the options for the forthcoming Phase 3D satellite. Reference [3] is already a major contribution to this field and signposts routes for further exploration.

Chicken Run

Doubtless during 1996 the usual "Chicken Little" re-entry competition will be run for Oscar-13. The author's

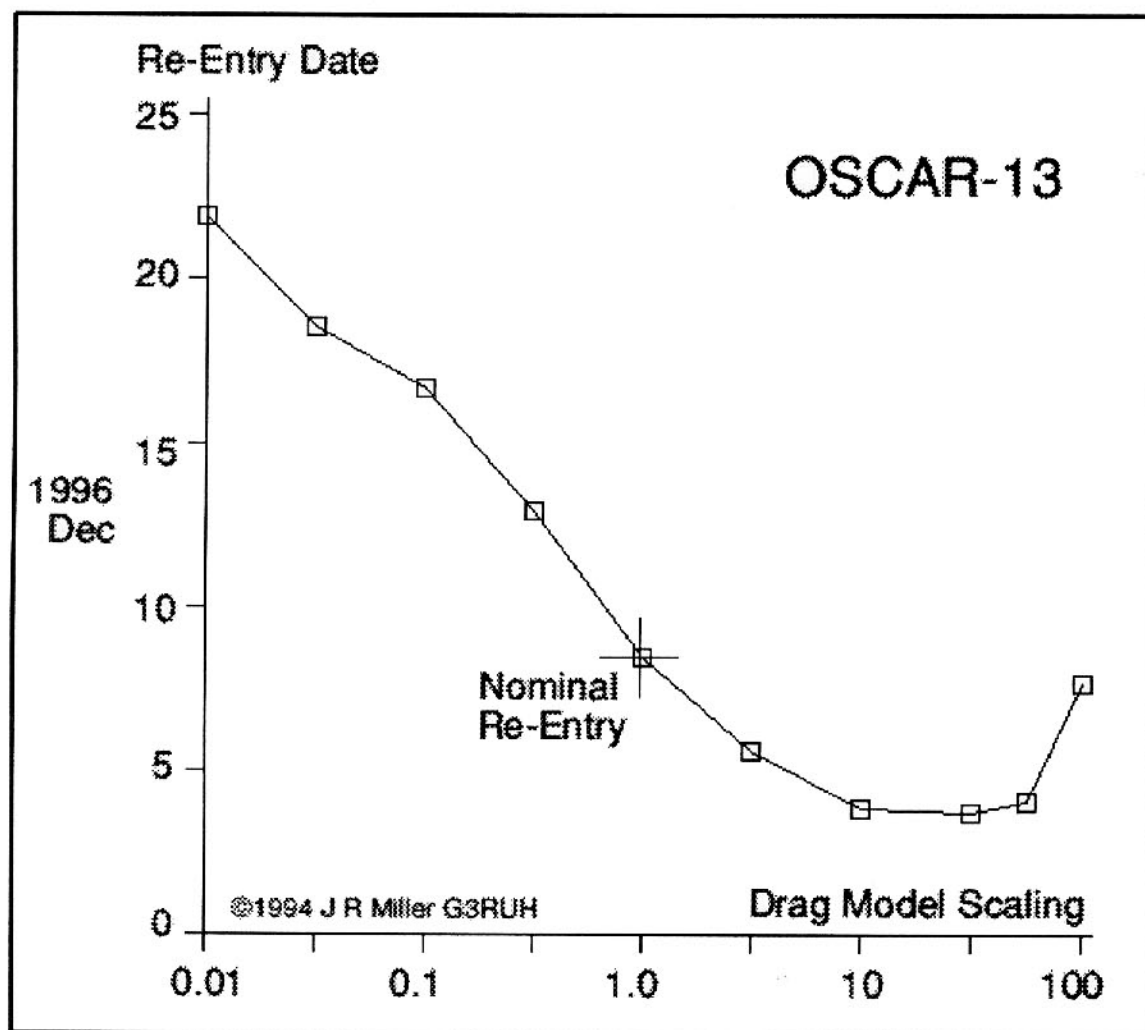


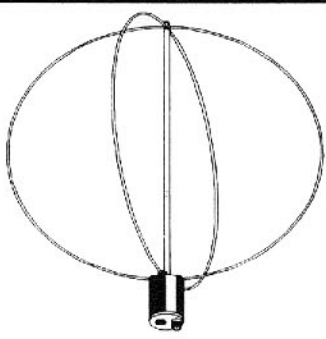
Figure 6. Re-entry date vs. drag model scaling.

prediction is 12:00 UTC, December 5, 1996.

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Heard on the Downlink

by John Hansen, WA0PTV

You may have noticed that this column has been missing from the Journal for the past few issues. The truth is, it is very hard to write a "heard on the downlink" column when I haven't actually been on the downlink. Any downlink. Last January I did an assessment of my amateur radio related activities and discovered that I simply had not had the time to operate satellites in several months. For most of that time I had continued to allow my automated digital station to run, but even that had fallen by the wayside in recent months. I hate to tell you how long it has been since I've been on HF.

This has not been through lack of interest, but mostly through lack of time. My kids were requiring more of my time; my job was requiring more of my time, and while the AMSAT Journal was actually taking less of my time, it was still taking an awful lot of time. It struck me as somewhat anomalous that while I had spent years now reporting on the development of Phase 3D, the way things

were going I would have no time to operate it when it was launched. So shortly after the first of the year, I told Bill Tynan that it was time for me to throw in the towel. I didn't want to leave AMSAT in the lurch, so I gave them four months notice. During that time they actively searched for a new editor... and they found a good one. Russ Tillman takes over the helm this issue. Russ has kindly allowed me to continue to write this column and I am hoping that very soon I'll be heard on many more downlinks than has been the case in recent months.

In the meantime, I've been trying to catch up on my correspondence. There was a whole stack of outstanding letters... principally requests for software mentioned in this column. If you sent in such a request and haven't heard from me by now, it means something has fallen between the cracks. Drop me a note and I'll fix the problem.

Mode S: The Book

We have all been watching Mode S gain in popularity on OSCAR 13, especially since the demise of the Mode L transponder. From the vantage point of the Journal I was able to see the number of submitted articles in this

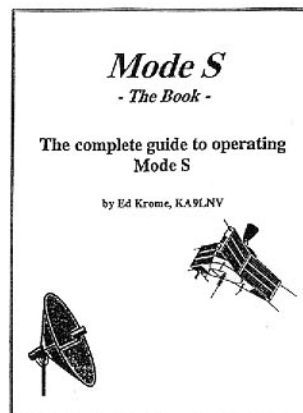
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area, as well as the number of inquiries about the mode, increasing a very rapid rate. So last fall I approached Ed Krome (who had written many of these articles) about the possibility of assembling a book on the subject. Rarely have I seen anyone take a ball and run with it the way Ed did. Shortly after the first of the year he submitted the complete volume for me to arrange for publication. Frankly, I was stunned by the size, scope, and overall quality of the work. AMSAT has published some truly great books in the last decade, but this surely ranks among the very best. Much of what is in the book has been previously published elsewhere. It contains virtually all of Ed's articles on Mode S that have appeared in the AMSAT Journal. It also contains a bunch of articles written by James Miller that have previously appeared in the AMSAT-UK flagship publication and elsewhere. It also contains material published in various ARRL publications. In addition it contains original material that has never before appeared in print.

The significant thing about this book is that it is all located in one place. At this point in time it is the single most comprehensive discussion of Mode S that exists anywhere in the world. If you have any thoughts of getting on Mode S (either now or for Phase 3D) or if you've come to realize that amateur satellite operation is inevitably moving higher in frequency and you want to begin to understand what the implications of that development are for your own station planning, or if you just want to know what all the noise is about, this is the book for you. It is available now from AMSAT HQ and is only \$15. Yeah, it's true, I'm not an entirely unbiased reviewer, since I was involved in the production of the book. So buy a copy, drop me a note and let me know what you think.

IPHONE - The Death of Amateur Radio?

One of the reasons I enjoy being involved with AMSAT has nothing whatsoever to do with satellite operation. AMSAT is made up

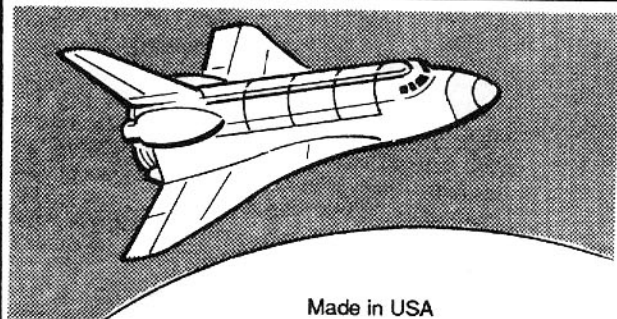
of folks who are a lot like me... they are interested (sometimes irrationally so) in new technology regardless of whether it has any immediate practical applications or not. So I look to satellite operators to find the latest in interesting technologies, some of which have nothing to do with amateur radio.

A few weeks ago I saw a note on the amsat-bb mailing list about a new product called iPhone. iPhone stands for Internet Phone and provides a mechanism for two computer users with sound cards installed in their computers to actually talk to one another in real time over the internet. Here's how it works... You run the software and log into a server site via the Internet. There you find a list of other people who are interested in talking (in another life we might call this "calling CQ"). You click on them and their computer rings (like a telephone). The next thing you know, you are chatting with them live. It's weird, because it is a lot like terrestrial radio in that currently it is a half duplex system... only one party can talk at a time. A full duplex system is set to be released soon (think of it as satellite communication). There's no QRM, no QRN, no QSB and really pretty good audio quality. I played with this for a couple of hours and "worked" six countries (including Hong Kong). I wonder if I can get DXCC this way?

Picture this: One evening I was lying in bed working on my laptop computer, as I often do. My wife is lying next me reading a book. Now, she has become quite used to me doing weird things with technology, but when the laptop said "Hi John, how you doing this evening" and I said to the laptop, "Hi Bob, how are things in Boston", she jumped. I was doing this over a 14.4 Kbps modem, by the way; it apparently doesn't require all that much bandwidth.

This raises all sorts of interesting issues. I suspect most long distance phone calls are sent digitally at this point. When I telephone someone in England and talk to them for an hour or so, the transmission of those bits cost me a lot of money. When I call the same person using iPhone, and transmit the exact same bits, the cost is zero (I get my Internet account from the local university). Even for those who pay for

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Internet access, the cost of an incremental hour of Internet has got to be at least an order of magnitude less than the cost of a hour phone call to the UK. Yet the bits are the same. How long can we realistically expect this price differential to be maintained?

iPhone is so much like radio that a couple of times I have caught myself just before I was about to drop my callsign in at the end of a transmission. It is interesting to note that a rather high percentage of the folks listed on the iPhone site have included amateur radio callsigns in the brief description they can post.

Oh yes, the iPhone software is not free. You can download a demo version of the software from the following site: ftp.vocaltec.com, but the demo version only allows you 1 minute of talk time before you have to reload the software. This is not as restrictive as it first seems and my impression is that the vast majority of the folks currently using it are using the free demo version. To get a full-blown version that allows unlimited talk time, you have to pay a registration fee that is currently \$59.

So is this the death of amateur radio? Actually I think it is not. One of the things that it has caused me to do is to think seriously about what makes amateur radio unique, and why it is likely that new facilities like iPhone (or the Internet generally) will not drive amateur radio out of business. So far, the following has occurred to me:

1. Round-table discussions are impossible on iPhone. This is particularly of significance to satellite operators in that the percentage of QSO's on, say, OSCAR-13 that involve more than two people is quite high.

2. You can't eavesdrop on iPhone. Most of my radio time is spent listening. I tune around and listen and often learn quite a bit. Many times I don't know whether I want to call someone until I've listened to them for a while.

3. You can't tune around. Is it just that I've been around too long or are tuning dials really important? I used to own an Azden PCS-2000 2 meter radio. The one thing I hated about it was that it didn't have a tuning knob; you tuned by hitting pushbuttons. With the Internet, I can "surf", but I can't tune. This is a distinct drawback.

The jury is still out on iPhone, but one thing is certain: It is one of the more interesting demonstration technologies that I've seen in a while.

Don't Send Your Money to AMSAT!

Relax, Bill, it's not what it seems. The ARRL has generously established a matching fund for contributions that are made to it for the purpose of supporting Phase 3D. So if you send in \$100, they will match it, and your contribution will actually result in \$200 going to Phase 3D. Now, a large number of AMSAT members are on the 5 year plan... that is, we promised to contribute a certain amount of money every year for 5 years toward the production and launch of Phase 3D. I'm sure that you can see what I'm getting at... If you are about to write out your check to AMSAT for P3D, it will actually be better to send it to the ARRL this year to go into the matching fund pool. Drop a note to AMSAT and let them know what you are doing so that you can still receive the sticker

that goes on your contribution certificate. It amazes me that time has flown by and we are so close to the launch. This is no time to nickel and dime the project... please send in what you can.

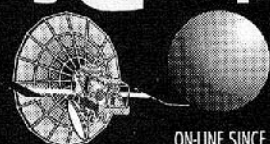
SSTV Revisited

The article the Journal published in the January issue on SSTV created quite a bit of interest. I heard from a number of people who are actively using JVFAX and enjoying it very much. I also heard from one fellow who took issue with my saying that \$20 for an SSTV adapter was overpriced. Now please note... In case you didn't notice, that comment was intended to be in jest. Anytime you can buy anything assembled for \$20 these days it's a fair deal, especially if it will send AND receive SSTV. And think about it... is it really possible that the AMSAT Journal's extolling the benefits of JVFAX is going to cut into the sales of pre-built units that support JVFAX software? So relax already.

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13th AMSAT Annual Meeting and Space Symposium

Orlando, Florida

Now is the time to start make plans to attend the 13th AMSAT Annual Meeting and Space Symposium to be held Columbus Day Weekend, October 6-8, 1995 in Orlando, Florida. This year's event will return to the International Airport Holiday Inn, Orlando, which was the same venue as last year's meeting. A Phase 3D update and tour of the Integration Facility are scheduled during the conference. In addition during the Space Symposium, the following members are scheduled to present papers:

Steven Bible, N7HPR, will explain his innovative development of a World Wide Web Ground Station that monitors digital satellites.

Tom Knisel, K4GFG, will talk about his experiments with the 6 billion-plus watt EIRP NAVSPACER CW signal to create amazingly accurate Keplerian elements using ham equipment.

David Liberman, XE1TU, will fill us in on UNAMSAT future activities.

Bruce Paige, KK5DO, will discuss the Houston AMSAT Net Re-Transmission by Commercial Satellites.

Keith Pugh, W5IU will bring us up to date on current AMSAT operations.

Peter Vekinis, KC1QF/EI4GV/SV4GV will provide some interesting commentary on Picosats.

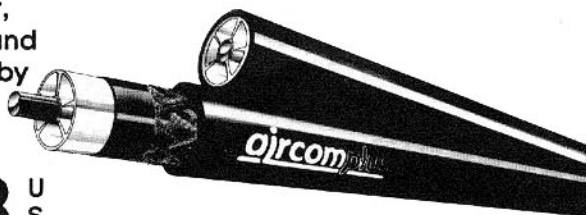
A block of rooms has been set aside at the **International Airport Holiday Inn** at the room rate of \$62.00 a night and may be reserved by calling 407-851-6400 or 800-465-4329. Registration information and forms will be provided in the July/August issue of the AMSAT Journal. See you there!

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SUNSAT: A MicroSatellite Under Construction in South Africa

With thanks to Dave Cowdin, ANS.AMSAT-NA, and AMSAT-UK's *OSCAR NEWS*

SUNSAT is a 60kg, 45 by 45 by 62 cm micro satellite being designed, built and tested by twenty Two M.Eng. students at the Electronic Systems laboratory in the Department of Electrical and Electronic Engineering at Stellenbosch University. Detailed design started in January 1992, led by Computer and Control System lectures. SUNSAT was originally designed for a sun-synchronous-type orbit on the Ariane 4 Helios mission, which is ideal for the main imaging payload. However, when launch costs became prohibitive, alternatives were sought.

NASA scientists have learned a great deal about the earth by detailed studies of the

magnetic field and the gravitational field, and have arranged for the Danish Oersted micro satellite to be launched as a secondary payload on a USAF Delta II from Vandenberg Air Force Base on the P91-1 Argos mission in January 1996. NASA and Stellenbosch have now agreed to carry SUNSAT into the same orbit instead of a counterweight for Oersted. In exchange for the launch, SUNSAT will carry a precision GPS receiver and a set of Laser retro-reflectors. These will enable NASA to study fine orbital perturbations for gravity field recovery, and for cross verification of GPS and NASA's laser tracking network. The orbit will be the same as Oersted, namely polar, 400 by 840 KM. The equatorial crossing will

initially be approximately 15:00 UTC, and drift an hour earlier every seventy days.

SUNSAT is a complex micro satellite. Its developers expect they will not have time and manpower to utilise all its possibilities, and hope that other amateurs and universities will become interested in using it once it is fully commissioned. Since this is their first satellite, they recognise this may take many months to get right. ■

[Excerpted from AMSAT-UK's *OSCAR NEWS*, R.J.C. Broadbent, ed., April 1995, Number 112, p 46.]

SUNSAT Microsatellite Communication Payload

by Jacques Roux

This paper was originally presented at Southern Africa AMSAT's 15th Annual Amateur Radio Space Communications Conference held at Johannesburg on 10 September 1994.

The SUNSAT microsatellite's communication system consists of three different systems — a VHF, UHF and S/L-band link. Redundancy, four different frequency bands and multiple channels increase the reliability of the communication payload. This paper describes what SUNSAT offers the radio amateur, and how the communication system works.

Introduction

The SUNSAT microsatellite is a small experimental satellite designed by students. Its major payload is an amateur communications system as well as a high resolution imager (+/- 15m pixels). The satellite also contains sensors, reaction

The Tenth Annual AMSAT-UK Colloquium

The Tenth AMSAT-UK Colloquium will be held July 27-30, 1995, at the University of Surrey in Guildford, Surrey, England. The AMSAT-UK Colloquium is the largest international gathering of amateur satellite enthusiasts and experts in the world and has established a high standard of quality presentations on topics relevant to the amateur satellite community. This year's colloquium will be divided into the following topic areas:

- * Spacecraft Engineering
- * Future Space Missions * Operations and Associated Amateur Space Activities

Everyone who has registered in the past two years will automatically be mailed a copy of the colloquium brochure.

Papers addressing any aspect of these topics are sought for the event. In addition, this year we are conducting a series of hands-on workshops to run during the event. Material suitable for presentation in the workshop series is also hereby solicited. While workshop presenters are not expected to submit a formal paper of their presentation, outlines and presentation notes would be welcomed for inclusion into the Colloquium proceedings. Authors (or presenters) should submit abstracts to arrive no later than May 15, 1995 with papers in final form (camera ready or on disk) to arrive no later than June 15, 1995.

The Tenth AMSAT-UK Colloquium promises to be the most informative and entertaining event yet. We look forward to your participation in this year's Colloquium. See you in Surrey!

Abstracts and papers only should be sent to the following address:

Doug Loughmiller, G0SYX
AMSAT-UK Colloquium Program Chairman
University of Surrey
Centre for Satellite Engineering Research
Guildford, Surrey
GU2 5XH England
Internet: D.Loughmiller@surrey.ac.uk
Facsimile: +44-01 483-259503

wheels and magneto torquers for attitude determination and control.

The VHF system is intended for the telecommand and telemetry up and down link as well as for amateur use. The S/L-band system will be mostly used for high-speed data transfer, but will be able to receive telecommand messages as a backup in case of disturbances on VHF or UHF frequencies.

A third subsystem, the UHF system will be similar to the VHF system, but will furthermore contain a QPSK modulator mostly for DSP use.

Figure 1 shows a block diagram of the communication payload. The UHF and VHF systems will work together and provide the primary communication link with the satellite. The S/L-band system will act as the secondary communication system, but mostly for high-speed imager data transfer.

The microsatellite will orbit the earth on an elliptic polar (+/- 100 minutes) path with the height ranging from 400 kilometers to 840 kilometers. This will guarantee a 15 minute line of sight time, with the distance ranging from 400 kilometers to +/- 2500 kilometers.

What will SUNSAT offer the Radio Amateur?

SUNSAT is mostly an experimental satellite offering alot to radio amateurs and schoolchildren:

A parrot system on the 2m-band which will relay +/- 8 seconds of speech, will create much interest among schoolchildren with novice licences.

A 2m analog channel for voice storage and transponder use.

MODE S 24cm/13cm linear transponder open for experimenters and TV relay.

Digital modes will also be incorporated for the following:

A bulletin board system (BBS) will enable the satellite to store files and other digital information in a 'mailbox'

Easy packet communication on the 2m band using a simple 1200 baud AFSK modem.

MODE J 2m/70cm 9600 baud FSK modem (G3RUH) mostly for national and international use.

Data from the imager will also be available on most of the downlinks.

Communication Payload

VHF and UHF System Specially designed 1/4-wave dipole antennas at 144MHz will be mounted on the four corners of the satellite to implement circular polarization. At UHF frequencies the antennas will be three times a 1/4 wavelength. The antennas will be rolled up during the launch and extracted after separation from the launch vehicle.

FIGURE 1: SUNSAT COMMUNICATIONS PAYLOAD

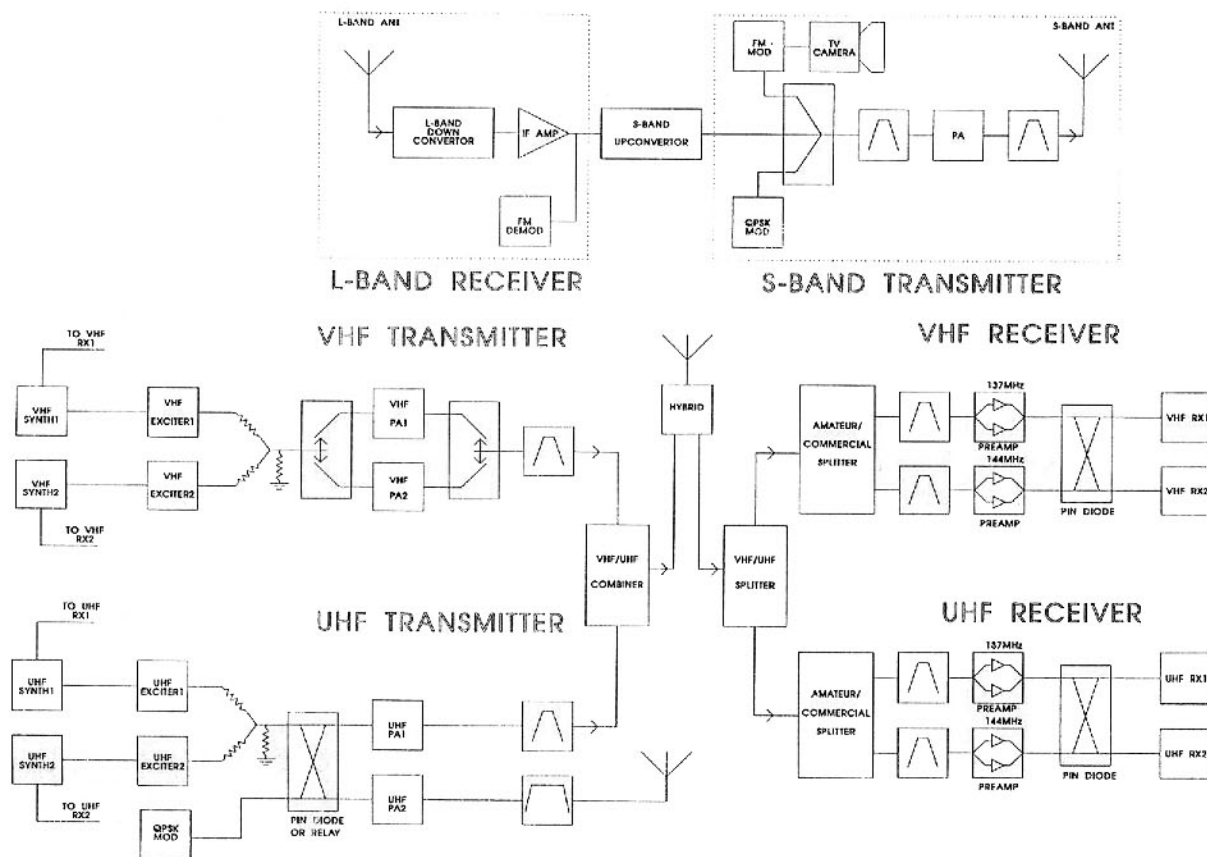


Figure 1. Block diagram of communications payload aboard SUNSAT.

The hybrid unit couples the transmitter signal to the antenna system for radiation and also couples the received signal to the receivers on the same antenna, obtaining -20dBs isolation between the transmitter and receiver.

The received signal is fed into a VHF/UHF splitter and is separated. A double redundant receiver system for VHF and UHF is then implemented. The received VHF/UHF signals are then both split for amateur (HAM) and commercial (COM) use.

VHF Receivers

Narrow-band helical band pass filters split the amateur (144MHz) and commercial (137MHz) channels also removing nearby transmitter RF power and noise power. The filters are followed by a low-noise, two-stage transistor pre-amplifier (NF=1.3dB) with a 30dB gain. This will keep the total noise figure under 2 dBs, for a 0.5 dB insertion loss due to the helical filters. Two pre-amplifiers are connected in parallel which can then be selected by a pin diode switch.

Either of the two channels (HAM or COM) can then be routed to any of the two receivers also via a pin diode switch. Both receivers are of the double superheterodyne type with IFs of 10.7MHz and 455kHz. The one receiver (RX1) is a single channel receiver and is connected to a dedicated 1200 baud telecommand modem. This receiver also has an extra IF output for use by the DSP.

The second receiver (RX2) is a four-channel receiver.

Both receivers have two onboard crystal oscillators at 145.825 MHz and 137MHz and a synthesizer input. The received signals strength (RSSI) signals of all the channels and the AFC signals, except for one channel, are available for telemetry purposes.

In the case of telecommand failure and when the satellite is reset, the one-channel receiver (RX1) will be always on.

UHF Receivers

The UHF system is similar to the VHF system. The input signal is filtered before it is amplified. The amplified signal will also be routed to either of the two signals. Both receivers have one channel and are precisely the same. The receivers also have two crystal oscillators and a synthesizer input.

To minimize the weight of having a synthesizer for every receiver and exciter, one exciter and one receiver use the same synthesizer unit. The synthesizer has a 20MHz frequency span from 110MHz to 130 MHz in steps of 5 kHz.

The output of the exciters is summed and fed to the two power amplifiers. The class-C power amplifiers have two modes of operation, a default mode of 1W to increase battery life and a 10W supplementary mode. The outputs of the power amplifier can then be switched onto the transmit signal path input of the hybrid via a transmit multiplexer (relay or pin diode switch).

Finally the transmitted signal is filtered to attenuate unwanted RF signals in out-of-band frequencies before radiation.

UHF Exciters

The UHF transmit system is precisely the same system as the VHF system except for an extra QPSK modulator used for transmitting high-speed data from the DSP.

The sum of the exciter outputs and the QPSK modulator output can then be routed to any of the class-C amplifiers which will then put the output signal on either a wide-band extra antenna or the UHF/VHF combiner unit.

Both the UHF and VHF systems have their own power unit supplying stable and clean

outputs of 5V or 14V. The synthesizer has a 6V input with its own 5V low dropout regulator.

S/L-Band Secondary System

The uplink takes place in the L-band and the downlink in the S-band.

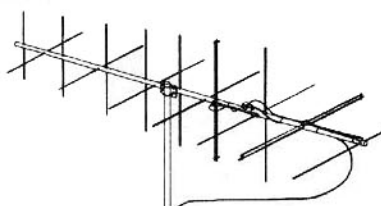
The main function of the S-band transponder is to use the S-band transmitter for downlinking high-speed data from the imager. A video signal from an onboard camera can also be FM modulated and downlinked via the S-band transmitter. The transponder can be used to relay high-speed data and video signals. The L-band receiver can also be used to upload software to the satellite's onboard processors and as a backup receiver for telecommand signals.

Conclusions

A communication system was designed using redundancy and wide frequency selectivity to improve the overall reliability of the communications payload.

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Beginner's Satellite Workshop Announced

A six-hour seminar on amateur satellite history, construction, and operation will be held in late July at the ARRL New England Division Convention. Become an expert operating through digital satellites, the "easy-sats," low-orbit and high-altitude satellites, the future Phase 3D satellite, Russian satellites, and learn a bit about Russia's MIR space station and NASA's SAREX missions. You'll see demonstrations and learn how to use FM, SSB, digital and CW modes, including dial-in access to a packet satellite without spending money for equipment, via a satellite gateway node. You'll see samples of building materials for satellites, and a slide show from the assembly facilities. When you leave, you'll know:

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Antennas, Rotators and Feedlines

Software for Tracking

Operating Protocol and Hints

What Information is available for You from ARRL and AMSAT
Frequencies—What Countries or Regions you can work

See You There!!

WHAT: Amateur Satellites — Today and Tomorrow

WHO: Steve Ford, WB8IMY ARRL Editor — QST's New Ham Companion

Keith Baker, KB1SF AMSAT-NA Executive Vice President

Barry Baines, WD4ASW AMSAT N.Fla Area Coordinator

WHEN: Friday July 28th, 12 Noon (After lunch) to 6 pm. Arrive early to get materials.

WHERE: ARRL New England Division Convention

New Hampshire Convention Center — Manchester, NH

[Holiday Inn Center of NH (603-625-1000) has a special ARRL convention room rate — if they're full, call 603-487-3333.]

HOW: Space is limited; to pre-register write or call Rosalie White, WA1STO, at ARRL HQ (tel 203-594-0237, fax 203-594-0259) before July 13. Price is \$15 for ARRL members and \$20 for non-members (part of the proceeds go to ARRL's Phase 3D fund-raising drive). You'll receive free materials and 6 hours of practical information. Sponsored by ARRL and AMSAT. You can also purchase *Satellite Experimenter's Handbook* from ARRL beforehand, for \$20 + \$5 UPS S&H.

Those who take part all day earn a certificate for 0.6 Continuing Education Units.

AEA's ST-1 Satellite Tracker

Advanced Electronic Applications, Inc. has a solution for satellite tracking and tuning—the ST-1 Satellite Tracker. The ST-1 offers satellite users hardware and software for automatic satellite tracking and transceiver tuning. The ST-1 connects to your PC computer, your computer compatible transceiver, and your rotors. The ST-1 uses one serial and one parallel port. Pass through connectors allow use of ports when the ST-1 is turned off.

Here's how it works: As the satellite nears the horizon, the ST-1 points the antennas in the proper direction and tunes the rig to the right up-link and down-link frequencies. As the satellite moves into the field of view, the ST-1 controls the antennas' tracking. The ST-1 also controls transceiver tuning, correcting for the Doppler shift throughout the pass.

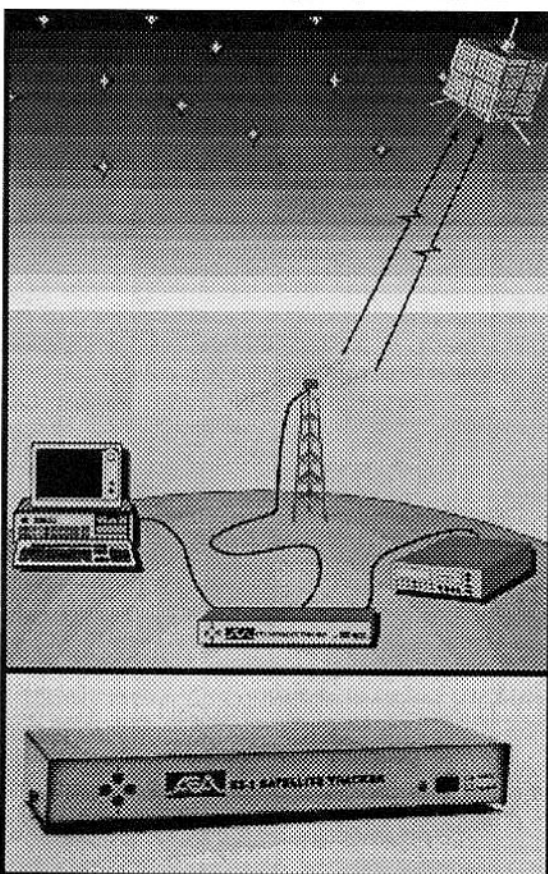
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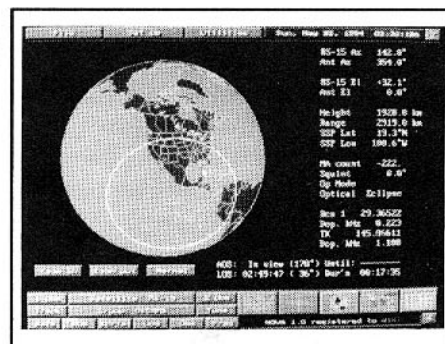
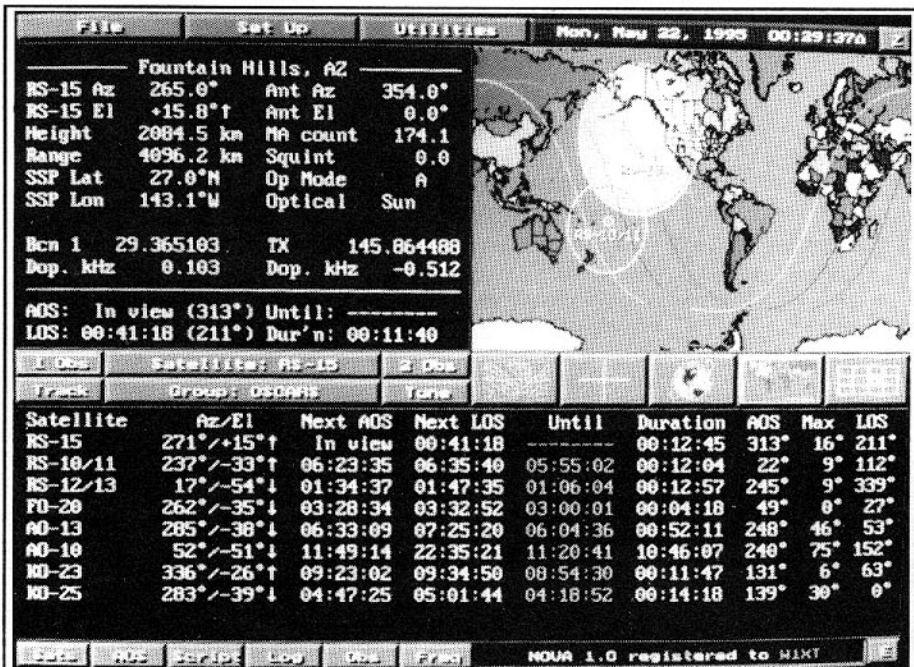
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Nova

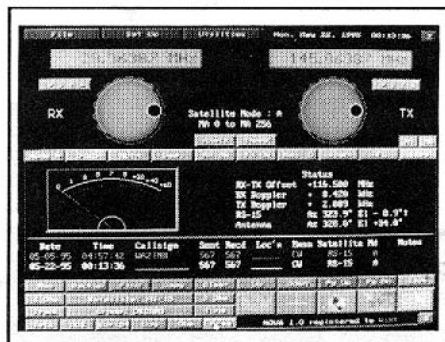
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That Does Much, Much More!



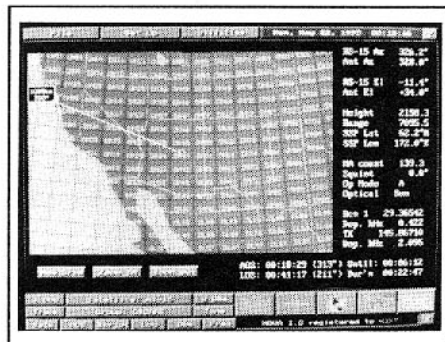
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